THE

WORLD A WORKSHOP;

OR, THE

PHYSICAL RELATIONSHIP OF MAN TO THE EARTH.

BY THOMAS EWBANK,

AUTHOR OF "HYDRAULICS AND MECHANICS."

NEW YORK:

D. APPLETON AND COMPANY,

346 AND 348 BROADWAY.

1855.

TO

WORKING MEN,

THIS LITTLE VOLUME IS INSCRIBED,

AS A

Testimony of Respect

TO THE

DIGNITY AND OMNIPOTENCE

OF

ENLIGHTENED LABOR.

PREFACE.

I am not aware of a single sentiment in the following pages to which the most devout mind can justly except, nor of a thought that is not in harmony with the deepest tone of admiration for the works of God, and with the purest feelings of love and reverence for Him; yet so it is, that kindred subjects are seldom brought forward without awakening opposition in persons who imagine the Ark of Truth endangered by the enunciation of speculations and deductions in science not included in their creeds, and who, on such occasions, eagerly put forth their hands to uphold it—as if it could be shaken or overthrown by error.

Truth, or rather the knowledge of it, is progressive. In nature there can be no end to its disclosures, for nothing is concealed. Upon every object, from an insect to a world, is written the purpose for which it is made. We may not always read aright, and no wonder, since we live in the infancy of systematic inquiry, and therefore cannot anticipate the results of its maturity; but our errors will be corrected by our successors, and theirs by those who succeed them.

That this mundane habitation was designed and literally fitted up for the cultivation and application of chemical and mechanical science as the basis of human development, will, I think, appear evident even from the imperfect examination here given it; and that it is essentially the same with other worlds, according to the condition of matter in them, and the physical constitution of their inhabitants, is all but an inevitable conclusion. To those who deny them to be centres of reasoning and active populations it is useless to reply till they can show for what other purposes they were made, and how this little earth, a mere atom among them, became so strange an exception. If we had had no knowledge of the existence of other orbs, it would have been unphilosophical to insist there were none besides our own; but now that we know they crowd every region of space, it would be positive folly to contend that all are barren of life and intelligence, of science and arts, except the one given to us.

It is preposterous to suppose the Divine Builder erects tenements for the purpose of keeping them empty. If they are not occupied, it is because they are not yet prepared to be so. It may be assumed that as soon as an orb is fitted for tenants they are put in possession of it; and then it is that another marvel is disclosed. Material natures require something to *do* as well as to reflect on; this is indispensable to their being—the purpose of it. *Employment* is, therefore, an element of existence, and hence, *The industrial activities of the denizens of the universe*; involving, as they must, infinities of modes and processes, and multiplied infinities of applications and results. The means by which this diversity is brought out might, on a first thought, be deemed inscrutable and incomprehensible, yet, like the effects of gravitation or of any universal law, it is very simply evolved. It depends on the diverse conditions of matter and the circumstances under which it exists, and as these cannot possibly be the same in any two worlds, much less in any two systems, neither can the occupations of those employed on it. These are, therefore, endless in numbers, because endless are the truths of which matter is the vehicle, and the applications of which it is capable.

Let those who do not sympathize with the idea that occupants of worlds around us act on matter as we do in this one (which, it should be remembered, is an integral member and sample of them), look abroad, and see how the same general laws to which it is subject govern others; how some in its vicinity resemble it in volume, density, duration of days and nights, &c.; how the red soil, green seas, and northern snows and ice of Mars approximate to it in these particulars; how larger, more distant, and more resplendent ones, belonging to the same group, are illuminated every night, each with several moons; and how in aerolites we have metals and metallic alloys belonging to celestial regions—and then ask themselves if there is anything unreasonable or unlikely, or if it is not in the highest degree probable and presumable, that people there add to their enjoyments and multiply their conveniences, by employing the materials and agencies placed at their disposal—in other words, that occupations akin to some of ours are followed in the other spheres.

Creation is not a medley of mingled purposes and disconnected things. The unity of design manifested in it is the theme of every philosopher, and not less observable and admirable is the fine chain of relationship that binds all the diverse forms and conditions of matter in one coherent whole. There are no violent transitions from series to series, but by almost imperceptible degrees differences open into species, species into genera, and genera into wider classes. And as with the contents of worlds so with worlds themselves; for they are merely larger divisions, and not the largest, since they merge into groups or systems, and systems, in all probability, into still more and more comprehensive departments. They are as intimately related to one another as are minerals, animals, or plants; and though we are not permitted to observe the alliance in their internal details, it is proclaimed externally to the utmost bounds of the heavens. There are no abrupt chasms in their outlines, dimensions, illumination, or movements, and by the strongest of analogies there can be none in their internal administrations.

In the latter respect the chain can be no more ruptured than in the former. The absence of the smallest link would break the continuity of the whole, and introduce disorder. On a matter so momentous, so overpowering in magnitude, as the interior economy of worlds, it would seem impossible that our orb should be the only one on which practical science is cultivated. There cannot be so wide a gap. There must be others more or less closely allied to it in this as in other respects; some in which the arts are prosecuted with higher and some with lower results. No truth is more patent than the unity of creation. There is nothing *sui generis* in it; nothing that stands solitary or alone—nothing that is not connected with and dependent on something else—not a boulder, a planet, or a sun, not an animal or the habits of one—not an order of intelligences or an occupation of intelligence.

Besides the varied and ever varying phases of matter, there is another law which still further affects occupations. It is that which is manifested in the diversity of mental organizations—in the genius, tastes, subtlety, and power of the elaborators. No two minds of like construction and calibre are found on earth; nor, from a common principle pervading creation, can be found anywhere. A general resemblance or type may prevail in single orbs, and even extend with modifications over a group, but the probabilities are that the differences as respects worlds and systems are quite as marked as we find them in individuals and races. "On a planet more magnificent than ours, may there not be a type of reason of which the intellect of Newton is the lowest degree? May there not be a telescope more penetrating and a microscope more powerful than ours; processes of induction more subtle—and of analysis more searching—and of combination more profound? May not the problem of three bodies be solved there—the enigma of the luminiferous ether unriddled—and the transcendentalisms of mind embalmed in the definitions, and axioms, and theorems of geometry? Chemistry may there have new elements, new gases, new acids, new alkalies, new earths, and new metals; geology new rocks, new classes of cataclysms, new periods of change; and zoology, mineralogy, and botany new orders and species, new forms of life, and new types of organization, all demanding higher powers of reason, and leading to a warmer appreciation, and a higher knowledge of the ways and works of God. But whatever be the intellectual occupations of the inhabitants of the planets, who can doubt that their object is to study and develope the material laws which are in operation around them, above them, beneath them, and beyond them in the skies!"*

But it is objected that physical industry and ingenuity are of too low and ephemeral a nature to enter into the sublime and everlasting plans of the Author of the Universe; that cultivation of *mind* must be the object of calling *it* into existence. True; but as matter is the agent on which God has printed his thoughts, may it not be the book which all minds are to read and to learn from? We know that he *has* made the elevation of human nature to depend on the study and application of principles impressed upon matter, and

* North British Review, May, 1854.

therefore it is consistent with his purposes and with his greatness to educate intelligences by means of it. And if one class why not two, or ten, or all? We know not that any are, or *can* be trained up without it; and as, wherever intelligences are, they are surrounded by it, and by displays of Divine wisdom shining forth in it, is it not reasonable to infer that it is a universal medium of mental and moral tuition? for which purpose, instead of being collected into one inhabitable body, it has been gathered into an infinite number, every one different, and a theatre of different phenomena.

There must be something wrong in the general dislike to material labor, and to the association of it with other orbs. Few persons, lay or religious, feel comfortable about it, because they are not impressed with the cardinal truth that matter is the agent by which God everywhere proclaims himself; and that in it are sources of knowledge sufficient to exercise all orders of intelligences for ever.

If "pride brought on the Fall," its effects are awfully felt in the low esteem in which the elaboration of matter is held, and in the presumption that it is derogatory to spiritual exaltation. Thus the original law, "Replenish the earth and subdue it," is regarded by most persons as a coarse, unpleasant, and unintellectual task, because its full meaning, and its bearings on our present and future destiny, are not perceived. Dwellers on the rest of the planets, we may almost be sure, received an equivalent injunction, and their happiness is made to depend on yielding obedience to it.

But it is to our own star that these pages are devoted. From careering among other worlds let us alight upon it, and scan from a stand-point that has seldom been occupied, the ceaseless labors of its living swarms. All are workers in and modifiers of matter. To man in common with the rest a task is given which, if fully understood, would place in a new and a better light this much abused orb of ours. It is the opinion of many that decay has seized its vitals, that its resources are approaching exhaustion, and the arts their climax; whereas in reality it is a spring of physical truths which man can never run dry. To suppose their current manifestations final is wrong, for before half of them can be found out and made use of new developments will have opened new tributaries. Chemistry and Physics, as the exponents of inorganic bodies, and Botany and Zoology of the organic, will pour, and continue to pour forth new elements, combinations, forms, forces, and motions. We have had pleasing illustrations of this in our day which, so far from inducing fear of the font failing, are prophetic of its fulness.

WASHINGTON, *August*, 1854.

CONTENTS.

INTRODUCTORY CHAPTER.

SECTION I.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

SECTION II.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

SECTION III.

CHAPTER I.

CHAPTER II.

CHAPTER III.

THE WORLD A WORKSHOP.

INTRODUCTORY CHAPTER

There is a series of initial and very remarkable facts in the present condition and disposition of the matter of our globe that have, I think, been little regarded. They have not, that I am aware, been considered in the light in which they are here presented to the reader, although singularly illustrative of the character here given to man—a character with which all terrestrial phenomena accord; the volume of the Earth, the quantity, varieties, and qualities of its materials; the difference between its internal and external products, its central fires and internal movements, its atmospheric envelope, the alternate illuminating and darkening of its surface; the physical and mental constitution of man; his necessities, enjoyments, aspirations, and morals; the duration of his life, and his education for a more enlarged sphere of existence.

The title has been selected for the purpose of arresting some fugitive thoughts, in the hope that scientific writers will add to their number, amplify and arrange them into a regular treatise on a subject fertile as the earth itself; and under the impression that they will serve to explode those vague impressions that so generally prevail respecting the real relationship between us and the globe we inhabit. Instead of universal confidence arising from settled conviction, uncertainty is almost everywhere felt as regards the extent to which we should give up ourselves to the earth. On the one hand it is viewed as a mere caravanserai, a temporary convenience for passing travellers, and therefore unworthy of more than passing regard: on the other are men active in exploring its resources, drawing from it elements of progressive civilization, and reflecting streams of light on the attributes of the Creator, and on his intentions towards us.

Let any one whose mind the subject never entered think within himself: For what was this spherical mass of materials made? To what special, or partial, or general uses was man to put them? Or was he to do anything with them? The questions involve the character and designs of the Creator, and the very basis of human welfare; for how are we to work out our destiny if we know not what it is?

It does seem strange that men should never have definitely determined the predominating characteristics of a world they have so long occupied; that they should have fluttered and fumed and busied themselves, like insects, on little isolated hillocks, instead of taking a view of the entire establishment and blocking out a working plan of the whole.

A glance at the countless occupations of men; at the divisions and subdivisions of material and speculative labor; at the bustle of trades, schemings of the ambitious. and struggles and competitions of all; would almost lead one to conclude we had been thrown at random on the earth, and left to scramble by chance for a living upon it. Reflection, however, points to a rule or law pervading the hubbub, and shows the diversities of pursuits to be offshoots of a primordial one which arises out of the constitution of the globe and our own organization.

It is conceded that the earth is in every respect fitted for man and he for it; and it might *à priori* be inferred that amid the multitudinous adaptations, there would be some ruling one to which the rest were to be collateral, or in which they centred. It was not probable that his abode was to consist of a mass of miscellaneous accommodations without character as a whole, or that his faculties were to be a heterogeneous compound without reference to some predominating task on which they were to be employed. What then was it that was so conspicuously to mark his connexion with the earth, and more than anything else proclaim him lord or lessee of it? It was the character he was to assume as a MANIPULATOR OF MATTER. The earth was to be a manufactory and he a manufacturer. It was to furnish him with unwrought material, while the sounds of his implements acting upon it were to swell till their reverberations rolled over the whole. His connexion with it, then, arises from the work assigned him, the materials for it, and the uses to which he is to put them.

It is, of course, from the materials of the earth and their attributes that its character is to be deduced. If they are adapted to man's wants, and to be operated on by him; if they are indispensable to him and yet useless till manipulated; it must needs follow that it was designed for a Factory. If it were wholly vegetable, it would be a Farm; if its products were objects ready for use, a Bazaar. But almost the whole is mineral—inert, unshapen, and unwrought, while even vegetable and animal substances require elaboration.

If, as some say, the materials were collected and arranged as we find them, to afford a platform for living creatures and a surface vegetation to sustain them, the vast subterrene minerals would be superfluous—an idea utterly irreconcilable with the wisdom of their Author. The hypothesis, also, that the chief employment of man was to till the soil and raise cattle, is an unworthy one, since it puts us much on a par with the lower tribes, in making the procuring and consuming of food the principal object of our being. If we were made to live like cattle—merely to eat and sleep—it would be true, and the earth might then be considered a mere victualling institution. But with us, and all intelligences, food is, like the traveller's staff, an adjunct of life, a mere aid in accomplishing the purposes of existence. Hence, though agriculture must always be a marked and honored department of labor, it is not the only one, nor the chief one. The portion of the earth's materials taken up by it is moreover comparatively small, and therefore the bulk of mundane matter was designed for something to which the raising of food was to be subservient.

While most persons think not, and care not, what the prominent character of the planet is, many view it in aspects congenial to themselves: a theatre for politicians, a battle-field for warriors, a court for lawyers, a lounging-place for people of fashion and leisure, &c. Morbid minds make it a crowded hospital and charnel-house, while the Indian believes it was made for nothing else than hunting game in. With these, and all surface dreamers, its vast underground treasures are not thought of. The inorganic world, its forces, principles, and processes, are to them as if they were not. It is only as a Factory, a GENERAL FACTORY, that the whole materials and influences of the earth are to be brought into play; and with this professional character of our globe every feature in creation will be found to harmonize.

For what classes then chiefly was the world of inorganic matter provided? Observe that dwelling; it belongs to a family neither rich nor poor; neat, commodious, and attractive in itself; it has a garden in front, an orchard and corn-field behind. Mark the social enjoyments, intelligence, and contentment of its inmates; the abundance of necessaries, of comforts and conveniences; the ornaments and elegances in dress and furniture, with contributions from almost every productive and decorative art. But, hark! a train of cars is approaching. It stops one moment and starts the next with a shriek for the city, whirling us along level and undulating lands, through tunnelled mountains, over rivers on bridges of granite, and others of iron. In the quick-moving panorama arise before us, and in a moment pass by, brick and lime kilns; potteries; tanneries; grist, saw, paper, and cotton mills; foundries; machine shops; chair, cloth, and carpet factories. We come in sight of a bay, on which ships laden with foreign merchandise are floating in with the tide, and others with home manufactures passing out. Crossing over in a steamer we find an extensive border of leafless forest resolved into masts of vessels crowded into continuous docks, and on landing, feel the air rent and agitated, like rippled water, with the noise of stevedores and draymen. We have business to transact for a friend, and pick our way along the side-walks, among packing-cases of dry-goods, casks of hardware, bundles of sheet and hoop iron, and loads of other goods. Next we stop at a telegraph office, and in five minutes our friend, though two hundred miles distant, receives and answers our note. On leaving the street of merchants for others occupied by watchmakers, jewellers, opticians, philosophical and musical instrument makers, engravers and printèrs, we call at a newspaper office to insert an advertisement and order the daily sheet for a neighbor. Need we proceed? It was for men who bring such things out of inert matter that this world of matter was made.

The proposition is sustained by a consideration—

I. Of the earth: its general features, materials, mechanisms, and forces.

II. Of man: his structure, instincts, and achievements.

To which are added—

III. Observations on prevailing mistaken views of matter, and of man as an operative, with thoughts on the universe of matter and of mechanism

A glimpse at a few outlines, or rather dots of outlines, on the gorgeous map which these inquiries open, can of course only be taken. Volumes piled on volumes would be required to fill them up, and the design is not to illustrate the subject so much as to call attention to it, assured as I am that no one can fervently enter *into* it without finding thoughts springing up within him, and prospects opening before him—such as inspired and uninspired poets would be glad to meet with.

SECTION I.

OF THE EARTH: ITS GENERAL FEATURES, MATERIALS, MECHANISMS, AND FORCES.

CHAPTER I.

PLAN AND PROCESS OF THE EARTH'S ERECTION.

If a wide, uninhabited district abounding in metals were discovered, and upon it an extensive antediluvian structure fitted up with all the paraphernalia of a complete machine-shop, no one could doubt the object of the ancient owner. Equally clear and palpable is the purpose of the Builder of this earth, as made manifest in its construction and factory appurtenances. It is such a shop. Examine the plan and process of its formation; its granitic foundations, superincumbent courses, and the precision and deliberation, so indicative of stability and durability, with which they have been laid; note the rich variety with the stowage and arrangement of materials for manufacturing purposes; how the earth is full of them, and how those most wanted are most abundant and accessible.

And observe, moreover, that when the edifice was finished, working-stock secured in its vaults, with machinery to raise it, and everything else prepared for the reception of workmen, then, and not till then (since there would have been nothing for him to do), was man called in to take possession and go to work. In the early ages of its erection, when all was chaos and commotion from the general displacement or rather want of arrangement of its materials, what could he have done? And in the calmer periods that succeeded as it approached completion he could only have been in the way. God employs no idlers—creates none.

While the first clays, sand, metals, and coals were being digested and put in their places, the condition of the atmosphere was such that he could not have inhaled it and lived. Neither food, climate, nor suitable arenas for his exertions were then provided. Like one of his own structures, the factory required to be warmed, ventilated, and furnished, before its intended occupants could enter with safety.

The character of a factory, as stamped on our globe, is also evinced in its materials being made amenable to human power. This is apparent to every one, but not perhaps equally so that it results from a law which has determined the inertia of matter with reference to human strength. This law lies at the foundation of physical science and arts. Had the earth's substances been too heavy or too light, or had they in other qualities, as hardness, softness, brittleness, toughness, &c., defied us, we could have made little use of them. But they are in all respects made subject to man, while their properties are specially and indeed wonderfully adapted to the exercise of his faculties. Many are doubtless yet to be discovered, but none can eventually elude or resist him. Already, he arrests the most evanescent and subdues the most stubborn; invisible and intangible airs he manages with the same certitude as liquids and solids; lightning he evolves at will; as his messenger it is kept flying to and fro over the face of the earth; besides which he is daily finding new employment for it in the workshop. It can henceforth know no rest.

Nearly all matter is inorganic. The great mass of the earth—the whole of it except its skin-like surface, is such! What does this mean? Why all this immature matter, unless it be for man to work up? How otherwise are its quantity and condition to be accounted for? The rest of creation God himself has elaborated into organisms that breathe and move, grow and live, throw off their products at stated periods, and perpetuate their kind; while the entire mineral kingdom lies passive at man's feet awaiting his action upon it: for in it are agents indispensable to his elevation, the very substances his necessities call for; and here is no one else appointed to use them—no one else that can use them. Could spoken language be more explicit?

Then what is more expressive than nature's limited elaboration of this matter, coinciding so perfectly as it does with the design of making man a workman in it? She only brings it up to certain points, and then stops, because at those points his efforts were to begin. All things necessary for him and above his capacity or powers to produce were provided, but unwrought or partially wrought materials were given him because the ability to mould them to his wants and wishes was imparted. Had it been otherwise, metals had certainly been dug up in the forms of necessary instruments, vegetable fibre had grown in hanks of thread and in woven garments, glass and stoneware had been quarried, and boulders had been cubes ready for the builder's hands; while joists and boards and articles of furniture had been the natural fruit of trees. All substances would have been found in the most useful forms, if the power to put them into such forms had not been communicated. No fact is more prominent in the divine economy of the world than that man was to have nothing—absolutely nothing—done for him that he could possibly do for himself. This was essential to the development of his character as an artificer. By it exertion became inevitable, while the direction it was to take was not to be mistaken.

But contemplate the earth as a whole, and it will be found a perfect contrivance for preparing these materials. Its spherical figure exerts a direct mechanical influence on them. In consequence of the pressure of superincumbent strata, their density increases with their depth. If a gas were conveyed down far enough it would be squeezed into a liquid: send it lower, and it would become heavy and impermeable as lead or platina. The earth is, therefore, ever acting as a press of varying powers, forcing matter into less and less space, and producing a series of substances varying in their properties and densities from airs to metals.

Now the question may and perhaps has occurred to the reader—If all minerals are for man to act on, and those deemed the most essential, as the metals, are located at the lowest depths, how is he to get at them? If they were designed expressly for him, means would have been expressly provided to put him in possession of them. Certainly: and so they have. It was by those means that the metals and other solid bodies now on and near the surface, were brought up. The exigence called for a device that should raise materials through all time to the hands that were to use them. And what is the device? A "Caloric Engine" in the centre of the Orb, the best location to send up materials over the whole surface: an engine whose chimneys and safety valves are volcanoes, and whose action and diversities of action are subject to laws as definite as any that control a windmill or a water-wheel.

The continued energy of this Plutonic power is significant of much work to be done, and the more so when taken in connexion with the fact that the stock of unwrought material has hardly been touched. As long as the motive wheels of a factory are kept in high order there can be no intention of stopping the works. People, however, have always been disposed to measure the life and condition of the world by their own. There are still those who imagine it broken down with infirmity and age, and every now and then shaken with convulsions that augur a speedy dissolution. They see little in lightnings, tornadoes, and earthquakes, but supernatural contrivances addressed to human fears. They are, like children, alarmed at roaring furnaces, flowing and spurtings of metal, the dust, smoke, and deafening clamor of driving and forming gearing in iron-works.

Instead of a premonition of decay, the great subterrene prime mover indicates the reverse. Instead of a blind agent of destruction, it presents as fine a proof of forethought and conservatism in the Divine Proprietor as anything that can be named. But we are so accustomed to view such matters with reference only to our individual selves and to our own times, that we seldom view them aright. In this case we are apt to forget that it was not for us and our predecessors alone that this wonderful machine was contrived and put in play, but for supplying materials to all that are to come after us, through periods involving new arrangements of the earth's surface—transposition of its mountains and valleys, continents and oceans. We may think the supplies now on and near the surface abundant, and that it may as well cease working till they are consumed; but, in fact, its action being continuous instead of intermittent is one of its finest features, since its work is accomplished so gradually as to be generally imperceptible, and so quietly as rarely to be heard. Were it otherwise, its action would be violently impulsive; and its displacements of matter, instead of being local, would be universal, and universally destructive of life.

To look on the internal fires and forces of the earth, as some do, with dread—to view them as destructive agents held in check for a day of wrath—is intensely absurd and superstitiously wicked. They were benevolently ordained to furnish man with materials he could not reach, and to keep raising them to the surface as the surface supplies diminish. To them he will ever be indebted for minerals essential to him. A foot is a small portion of a mile, yet the deepest mines, compared with the distance to the centre, hardly exceed the proportion of six inches to a mile; how then could he have reached lower or even penetrated upper strata? We should have been ignorant of the metals, of our common building materials, of lime, gypsum, clay, sandstone, marble, slate, granite, and other rocks; for all these are formed at immense depths below us. We should not have known what the contents of our world were, or if we had, we never could have obtained them but for the Divine solution of this most interesting of engineering problems. Without it the destinies of man and his connexion with the earth had been very different from what they are.

Proofs of intelligence and design in the earth's strata thaw into admiration the most frigid of geologists; and is not this, the only imaginable plan by which every kind of matter stored below can be brought up for us, calculated to awaken as deep an interest! How simple, effective, and suggestive! The nearest device that occurs to us are the steam-engines in the deep cellars of government stores that send up samples and bales of goods as merchants call for them.

CHAPTER II.

ARRANGEMENT OF THE EARTH'S MATERIALS IN STRATA.

One of the most characteristic features in the structure of the earth is the alternation of strata. It is built of layers of hard and soft, compact and loose materials, which are thus kept from running into each other and rendering the whole a disordered and confused mass. The system is eminently methodical and mechanical. If it were not that the lower matter is located in the earth, the more compact and adhesive, as a general rule, it becomes, much of it could not have been protruded as it has been. It would have crumbled and become mixed with, and lost among the detached and loose substances through which its passage lay. A bed of sand or clay could not be pushed up in an unbroken body through a hundred or through ten miles of miscellaneous materials, unless a plate of rock was interposed between it and the upheaving force, and without another above it to keep out other matters; hence the geological formation of alternate plates and of softer materials is precisely what mechanical philosophy and every day's experience suggest in analogous operations by man. Coal is of too friable a nature to be thrust up except between platens of rock. Lastly, these platens become dislocated more and more as they approach the surface, and thereby fulfil the remaining requisite—that of opening the contained beds to human observation and research. If the plates had remained unbroken their contents could not have been got at.

The strata of the earth have been classified in the following comprehensive orders, beginning at the uppermost and descending to the lowest:—

1. Consisting chiefly of sands and clays.

2. Comprising chalk; sands and clay beneath the chalk; then calcareous freestone, and argillaceous beds,

new red sandstone; conglomerate and magnesian lime stone.

3. Coal measures; carboniferous limestone; old red sandstone

4. Roofing slate and its cognates.

5. Mica slate: gneiss, granite.

"In all these formations from the lowest to the highest we find a repetition of rocks and beds of similar chemical compositions, *i. e.* siliceous, argillaceous, and calcareous, but with considerable difference in texture; those in the lowest formations being compact and often crystalline, while those in the highest and most recent are loose and earthy." *

Surely, no engineer can glance over the series without perceiving how admirably it is made up for the elevation of portions of every layer to the surface. Granite is the lowest. It is the hardest, the strongest, and an unstratified rock, as it ought to be, since, like the piston of an engine, it receives and transmits the upheaving power to all the rest. It breaks its way through all that overlie it, and bears up beds of them all with it, because of its superior compactness and hardness. Were the series reversed no such effects could have followed. We should not have known coal except from minute fragments picked up by collectors of rare minerals.

Then how the character of granite changes into gneiss! This rock is a species of granite, but from an excess of one of the elements, mica, its texture becomes lamellar and slaty. It is weaker than granite. Next, dropping

* Conybeare's Introduction to the Geology of England and Wales.

the feldspar ingredient, gneiss passes into mica-slate, whose components are mica and quartz—a still weaker compound, and one at which the stratified series begins.

"Although the five foregoing comprehensive classes serve to exhibit a general view of the great outlines of modern geology, we no sooner begin to trace in detail the succession of mineral beds, than their numbers and varieties appear to be endless, and but for some classification would be infinitely perplexing to the student. By grouping together individual strata in a natural and easy manner we reduce them to a limited number of series; each series comprehending numerous individual strata naturally allied and associated together. To explain this by an example. If Derbyshire be the country under examination, the investigator will find a series of twenty or more alternations of beds of coal, sandstone, and slaty clay, repeated over and over; and beneath these a like alternation of limestone strata, with beds of the rock called toadstone. Here, then, all the individual beds resolve themselves into two comprehensive series, the upper containing coal, the lower limestone; each series being characterized by the repetition of its own peculiar members."*

The materials of the earth are, then, constantly under the influence of two opposing forces: one urging them from the centre, the other, their prodigious weight or pressure, crowding them towards it. Here several interesting reflections are evolved, every one of which is a lesson in engineering.

* Conybeare.

1. If there were no internal force to interfere with the external one, the volume of the earth would grow less and less as consolidation proceeded. Contraction would continue till the maximum solidity was attained. The change from the present dimensions and density of the orb would probably be as great as if a three-inch ball of clay or sandstone were compressed into a half-inch bullet. At all events, the earth would become a quiescent, impenetrable body: no portion save what the surface exposed could be used, vegetation would be impossible, and, as a consequence of that, animal life impossible too. But all these, and other fatal results, are avoided by the central expanding force heaving up material in quantities sufficient to balance the effect of the contracting one.

2. Suppose the internal greater than the external force, then the diameter of the earth would increase with matter accumulating on the surface; but here also a compensating principle is at work. Mountains have been pushed up, but equal masses have settled down. Some lands are rising, but then others are descending. The ocean is creeping up some shores, and at the same time receding from others. Thus, the two forces are so adapted to each other, and act under such circumstances, that the earth neither swells nor shrinks. Did either effect take place, it would be destructive of stability and the present constitution of things, and hence life itself requires the continuous activity of the earth-quaking power.

3. But admitting the forces to be equal—as indeed they necessarily are, since the expanding one is due to the compressing one, the law of action and reaction being as fully developed in them as in anything else—then, if the

earth were composed of homogeneous concentric strata, no interior movements could take place, and consequently no materials be displaced. The forces would be in equilibrio like steam in a close boiler. Now, the way in which materials are brought up is singular for its simplicity, and the certainty of action under any and every contingency. That there is an irregularity in the thickness of the walls of the earth is certain; that is, unless there are cavities and protuberances at the centre corresponding with elevations and depressions without, a condition of things impossible, and all but inconceivable: hence there are *weak places* always in the walls, and upon such places the central force is expended. Besides inequality of strength arising from inequality of thickness, we know that homogeneity of strata has been broken by the upheaval of lower through upper series; and we also know, from the moderate mean density of the planet, that it is not now, whatever it may have been in the early periods of condensation, composed of layers of *uniformly* increasing densities. There is, therefore, an entire absence of uniformity in the strength of the walls; and the beautiful result is, that, while the external force acts continuously and uniformly over the whole, the internal one acts locally and in succession on the whole.

4. Were the performance of the central force different from what it is, it would be of no benefit to man. Suppose its action could be uniform on the whole, and just sufficient to prevent further contraction, like air confined in a bladder, or steam in a boiler, every thing would then be at rest, and no change of material on the surface could take place. But to originate and maintain internal

currents of matter upwards is its vital function. Without this circulation and exchange of interior and exterior substances, the earth might as well have been a shell, as some suppose it is, since its hidden treasures would for ever have remained hidden; whereas, by the existing arrangements, they stream upwards and return as through an immense colander. As near as can be, the movements resemble those of fluids. In a globe of water a current, the minutest and slowest, would keep varying the local positions of the particles, and causing those within and without to change places. In a ball of sand the same thing would occur if a central force started the movements. The earth is such a ball: its central force induces and maintains the currents, though they move at so slow a rate as to be almost irreconcilable with our accustomed ideas of fluid motion.

5. The material is sent up with the least disturbance, and the general arrangement by which this is accomplished is beautiful:—Thus, while the compressing force increases in intensity as it descends, because it keeps forcing the materials into less and less space, the expanding one diminishes as it ascends, from becoming diffused into ever widening areas.

In this admirable way, then, is all matter brought under human influence, and made to contribute to human enjoyment.

'All matter?' Yes! I do not think it is too much to assert that the whole was destined to pass, and that repeatedly, through human hands, preposterous as the thought may seem. God has made coal and ores for man to use—not to conceal them uselessly. If an approximate estimate could be made of what has been acted on from the beginning, or if even the amount now annually displaced, or otherwise made use of, could be ascertained, the idea of a scarcity rather than a surplus would be suggested; and, especially in view of a prolonged future, when the planet will, in all probability, be occupied by a dense working population, the arts and sciences universally extended, and inorganic motive agents abounding beyond our present conceptions. So far from an excess, a deficiency would inevitably occur, were it not for the continual recomposition of decomposed bodies—a principle that prevents the establishments from being closed for want of fresh stock to work up. There is no reason whatever to infer that the fertility of a surface layer can be indefinite in duration—that it can continue beyond certain periods to support vegetable or animal life. To recover or maintain its virtue, the material must descend into the alembic again. Like broken utensils and scrap metal, they must be recast; for the heat of the central furnace is as necessary to prepare materials for man as to furnish the power that pushes them up to him.

CHAPTER III.

THE SHELL THEORY OF THE EARTH UNMECHANICAL.

The hypothesis that makes the earth a hollow shell—a thin one, too, for the thickness has been estimated as low as fifty or sixty miles, which compared to the diameter is little thicker in proportion than the shell of the domestic fowl's egg—is not only a startling one, but it certainly conflicts with mechanical laws. Unless the shell was composed of perfectly homogeneous matter, uniform in thickness and truly spherical, it could not retain its figure; because the effects of condensation from the pressure of its materials would be unequal. If it were even of iron it would be crushed in, and more promptly than an irregular formed exhausted glass receiver. But the earth is known to be made up of anything but homogeneous materials; so far as observed, it consists, and down to low strata, of miscellaneous substances of exceedingly varied densities; of sand, gravel, ores, rocks, coal, clay, &c.: the whole forming a mass of material most unfit for a permanent arch or dome, most inadequate to resist uniform external pressure, and the less so when subject to be shaken and ruptured by earthquakes, and to wide displacements of matter. It may, we think, be assumed as an utter impossibility that a large proportion of the interior of the earth is hollow.

The idea that it is so is, of course, purely speculative. The whole globe is supposed to have been long in a state of ignition—an orb of molten matter, the cooling of which first at the surface caused that portion to solidify. The fluid within continued to congeal and thicken the walls, but shrank at length from them, and left a hollow space between the shell and itself; somewhat as if the yolk of an egg were to remain in its place after the white had been withdrawn. Besides other difficulties in the way of this hypothesis, the origin of the fire is one, and its beginning to cool looks like another. Why, after being once ignited, did not the matter continue to burn till consumed, or till the elements of heat were dissipated? What was there to hinder? If, as is said, caloric is now slowly leaving the earth, it would seem then to have had an opportunity to desert it altogether.

The hypothesis that originates worlds in whirling balls of fire, we think can hardly be surpassed in wildness.

It seems more philosophical, because consistent with known facts, to suppose the central heat the result of the earth's contraction—that it was slowly squeezed out of matter and driven to the centre by the pressure of the encompassing and superincumbent mass—just as we squeeze it out of air by a syringe, out of cold iron by hammering its particles closer together, or out of any substance whatever by compressing it. The elementary matter of the earth, it is not doubted, once formed a gaseous sphere whose radius extended beyond the moon, and which by condensation became reduced to its present dimensions. The caloric diffused through the immense orb has been slowly crowded in and become concentrated at the centre, whence it would again rush through the whole, if the whole were dilated as at first to make room for it. In this view the presence and the accumulation of heat at the centre of the earth are accounted for. It was, we suppose, developed, and is sustained by mechanical pressure, and to that, chemical and galvanic influences may contribute. There are also sources of heat in the inflammable metallic bases of earths and alkalies, and doubtless in many other matters at present unknown, but which science will eventually reveal.

Every planet, then, has its appropriate quantity of internal heat inherent in its materials, and must retain it while possessing them, though its manifestations may greatly vary. Some philosophers do not believe this. They think the earth's central fires are burning out, and that in time the temperature here will be too low to sustain life; but this is reasoning on God's furnaces from our own. True, the central heat radiates in the walls that inclose it, but, unlike ours, they are too thick for it to pass through. It is questionable whether any reaches the surface except through volcanoes and mines, while there can be little doubt that the sun supplies all, or more than all, that radiates from the surface and becomes, if any becomes, dissipated in space.* It is the great external heater of our planet, and the supporter of vegetable and animal life, while the function of the other is with inorganized matter. Great as the heat at the centre is, it is insensible at the surface, because the solar rays penetrate to a depth to which it does not seem to rise. As an inseparable and indestructible element of matter, the same quantity of heat or material of heat must continue, although it may not always be equally excited, or be in

* Suppose matter does escape from the surfaces of all the planets and in greater proportion from the sun, may they not all take up just as much as they lose, from the medium through which they are floating; for it now seems to be admitted that the regions of space are filled with a fluid whose density is sufficient to affect the motions of comets, if not those of other bodies? In this way space performs for all orbs the part which the atmosphere performs for ours—impereeptibly receiving and restoring the matter of which they are made.

the same circumstances for excitement; more or less may become latent by diffusion—more or less manifest by concentration.

It is singular how writers differ. There are those who suppose the earth's temperature actually rising, in consequence of the sun's heat being transmitted entirely through it by the conducting power of the ground. The accumulation of thin waves of heat moving inwards every summer resulted, it is said, in igneous liquefaction at the centre; and is eventually to result in the melting of the elements and in the earth's passing away as a scroll. Thus, between the two theories, it is either to become a dead and frozen body or be heated into gas, and that gas dissipated in flame. Then there are others who shiver when contemplating the outer planets, because of their being located so far from the sun; and yet the average surface temperatures of those orbs may, for aught we can see, be quite as high and even higher than that of the earth. Jupiter is over 1300 times larger, and the heat developed by the compression of such an immense volume of matter may more than compensate for its being five times the earth's distance from the sun. While solar heat preponderates on the surface of some, internal heat may surpass it in others.

The disposition to anticipate evil in the earth and in the heavens is a relic of the ages of horoscopes and omens: and so is that which lingers over an early winding up of the affairs of the earth, as that of an establishment no longer profitable; its occupants to be killed off by freezing or by fire, its roof and walls torn down and dispersed, and its elements used for building up a better one. Can a better one be made? Infinite wisdom may produce a different one, but not one more perfectly suited in every imaginable respect to us. It might be occupied by better tenants, but then there is no limit to our improvement if we choose to pursue it: and our species will improve. Men will advance spiritually as science and arts advance.

The power that produces earthquakes, then, so far from being a destructive, is eminently a conservative one. The stability of the earth depends on it; and it is as essential to the life of the world as the heart is to an animal. Neither has it been more fatal to human life than some of the arts. Who would decry mills because men have been drowned in dams, or gas-lights because they have set houses on fire, or foundries because workmen have been scalded by molten metal! Who would give up navigation by wind or steam because of storms! or travelling on railroads because cars have run off the tracks! No one. Neither do people quit the sites of cities or other places shaken by earthquakes. In time the phenomena will be better understood, will be accompanied with less loss of life. Premonitions of their coming, now misapprehended or unperceived, will then be construed aright and acted on.

Earthquakes have not been investigated with the care their importance demands. Their purpose, or the motive of the builder of the earth in establishing by means of them a constant exchange of internal for external matter, has yet to be taken up and philosophically considered. Sometimes locally calamitous, and at all times fearful from the magnitudes of their movements, and the utter helplessness of man to control or prevent them, they are anticipated with disquietude and witnessed with affright. This is just the conduct of those nervous persons who only contemplate steam in its explosion of boilers, closing their eyes to the benefits it confers on society. Earthquakes are the workings of an igneous engine that is infinitely more advantageous to the inhabitants of the whole earth than is steam to people who use it.

As a caloric engine simply, the earth's central force is interesting, and as the most compact and powerful one still more so. Planned and executed by the Great Engineer, it carries out his ideas of the best mode of displacing large masses of matter here; it therefore is a standing lesson to us on one of the most laborious and enduring departments of art. It is calculated and intended to initiate and instruct us in similar applications of the expansive force of fire; it suggests artificial volcanoes, which have accordingly been adopted by civil and military sappers and miners. The principle has been but partially employed hitherto. We believe it is destined to greatly more varied and extended uses. The simplicity of the regulation of the central engine has been adverted to. Were the power confined, like gunpowder in a shell, it would burst the world asunder; but by the absence of uniformity in the strength of the walls that encircle it, its perfectly harmonious and perpetual working is secured. The rending of the shell is impossible.

The earth's material, besides passing through or towards the glowing centre, circulates also through another and widely different receptacle. Into the atmosphere the constituent gases of all matter are received. It is the great dissolver of all. There is not an atom in our bodies, nor has there been one in the bodies of the dead, but what came from it; not one on the earth or under it but what has been in it. Towards one or the other of these laboratories all matter is progressing, and changing as it progresses, being urged on by the two great forces already named.

These laboratories, and the forces urging the contents of the orb through them, constitute one of the earth's chief working features as a whole—and a most interesting one in a mechanical aspect it is.

But there is a feature in the factory not yet noticed, by which the début of man was hastened, and one which everywhere had a direct, and will everywhere have a lasting bearing on both workmen and the work. It is this:—

The earth was not matured throughout at once, but only in parts, and as each became ready for man, he made his appearance on it. Its great sections are now in diverse stages of development. No two are of the same date. In recent as in remote ages the highlands were occupied before the basins were well drained. This is exemplified as much in the new as in the old world. The regions of the Andes have long been peopled, while the valleys of the Amazon, Oronoco, Parana, and other streams, are in the almost undisturbed possession of the lower tribes. Indeed, at this hour, a very large proportion of the earth is unsubdued—another proof that we belong to an early period of its history.

Thus it appears to have been a distinct trait in the

Divine plan that the factory should not be equally and uniformly matured. The advantages of this were great: Man was sooner introduced than otherwise he could have been; while growing up on one part, another was preparing for him. His materials and agencies were vastly multiplied; instead of having no animals and plants except such as belonged to his own epoch, he had around him representatives of all that had flourished from the beginning. And the same may be said of his own species, for at present there are as many varieties of men as have probably existed since the first settlement of the planet. Another advantage was, that the occupants of one part were made mutually dependent on and beneficial to those of others. In a manufacturing point of view the plan commends itself as the most economical and productive in every conceivable respect.

CHAPTER IV.

FIRE INDISPENSABLE TO THE FACTORY, AND TO MAN AS A COSMOPOLITE.

Before man could attempt earthen or metallic wares, he lacked another element; one neither visible nor palpable. He might knead clay into forms, but if he stopped there, they would remain clay. To succeed, he must, like Prometheus, animate them with the life and soul of the arts. It is fire that enables us to open the teeming earth and to use its treasures. Without it the artist and the artist's hammer, and all that they have done, had never been. The factory could not itself have been tenantable; and if it had, no work could have been done in it. Essential to man as a cosmopolite, his earthly pre-eminence rests on the exclusive use of fire. Withholding it from brutes was essential to his rule over them. Did they possess the power to elicit it, enraged by his tyranny they would set and keep the world in flames. His superiority would wane, and his tenure on earth be uncertain and insecure. To prevent this, special provision has been made. Animals fly from fire—a dread of it is implanted in their natures. Those that prey in the night are impelled by a law of their organization to avoid it; for when dazzled by the blaze of a torch, the contraction of their pupils amounts in some species to blindness, and in all the sight is affected. Hence, though many of the lower tribes surpass man in physical energies, speed, flight, duration of life, minuteness and magnitude of their works, happily none can strike fire, nor fan it into flame.

Still, lights in the night were not withheld wholly from the lower tribes. For those that required them, a special illuminating element was provided. There are some that surpass in numbers the human species, of which every individual carries a torch that rivals in brilliance the best of our candles, the materials for which they have the power to secrete. Glow-worms and fire-flies are familiar examples. In tropical climes, various luminous insects are attached to female head-dresses. They are used also as lamps. I have read fine print in a dark room by the light of two small Long Island fire-flies in a tumbler. But man was not the first to rob these living gems of their liberty and radiance. There are birds that seize and suspend them as chandeliers for their dwellings. The bottle-nested sparrow, or baya, is one of the kidnappers. Its nest is closely woven like cloth in the figure of a large inverted bottle, with the entrance at the orifice of the neck. The interior is divided by partitions into two or three chambers, one over the other. These are profoundly dark until lit up with fire-flies caught alive, and mercilessly fixed to the walls or ceiling with pieces of wet clay or cowdung for sconces.

How was fire first obtained? Does the reader know? If not, if he have never reflected on the subject, let him now reflect. The operation and materials must of course be suited to man's condition in the earliest days of his apprenticeship, since neither the metals nor anything like tools were in use: applicable, too, to all lands since untutored man first occupied them all. Suppose the reader were thrown ashore on an uninhabited island, without flint or steel, match or tinder, or any artificial substitute, how would he act? Unless he knew what the primeval device was, he might perish, as many have perished, for lack of the information.

The process was by friction, and the only instruments employed, two small pieces of wood. By twirling the point of a dry stick in a rude indentation made in another, or by rubbing it to and fro in a groove, sparks were evolved and flame obtained: an apparatus so simple that Indian boys and girls have been observed to prepare it by breaking suitable pieces from a branch and gnawing the pointed one into shape. Such, from the beginning, has served the wild man for a tinder-box; and thus, wherever fuel was, he had the means of kindling it. Viewed in any light, this was a remarkable invention. The blessings it immediately secured and those it has given rise to, mark it as the most memorable of pristine discoveries.

Who the first inventor of the device was, history has not informed us. The author of the Pentateuch takes no notice of it, though he mentions inchoate discoveries of less moment. One might have expected that in treating of man's origin and early progress, he would not have overlooked an art or device with which human enterprise began, and the introduction of which opened the leading act in life's drama. Ancient nations almost invariably ascribed it to their founders or patron deities: hence its incorporation in traditions, histories, and legends. The description, in one of Homer's hymns, of Mercury kindling a fire to roast cattle he had stolen, is literally that of a Camanche or Apache after a buffalo hunt, or a foray into New Mexico.

'And gathering fuel, the inventor rare
To fashion fire did his wits renew.
Hermes first taught how sparks could catch.
T'was he invented tinder and match;
For where the hard branches grew
He snatch'd a branch and stripp'd the bark,
Rubbed piece 'gainst piece, till spark by soark
Was kindled, and the flame upflew." *

The hint that led to the process, according to an old

* Translation in Blackwood.

tradition, was the ignition of trees by collision during a high wind. The story was preserved by Sanconiatho, and adopted by both Grecian and Roman writers. It is ingenious, but unsatisfactory. Forests may occasionally be fired by lightning; seldom or never, we believe, by friction alone. But leaving the question, which would divert us too far from the track of this Essay, it is worthy of observation that all primitive people, no matter how distantly located or how isolated, have kindled their fires by friction. In the eastern hemisphere, it dates from the first age or ages, and was universal. In fact, it was the device by which the Patriarchs and their immediate descendants obtained fire; and when these continents were discovered, it was found in possession of the natives from the Esquimaux to the people of Terra del Fuego, from those who hunted on the borders of the Atlantic to the tribes that dwelt on the Pacific shores. It was as familiar to the half-civilized occupiers of Chili, Mexico, Central America, and Peru, as were vessels to hold water. In the islands of the Atlantic, Pacific, and Indian Oceans, and through the regions of Australia, it was equally known.

Is it to be inferred that all these people derived the art from observing trees kindled by friction in a storm, or from a primeval source, when mankind is supposed to have been one family? We should say from neither, but that, like the bow, axe, lever, and canoe, it was an instinctive suggestion, and hence its universality.

It has been too much the custom to consider the simplest arts as having had one date and place of birth, whereas they certainly have been independently disclosed at different times and in distant lands. So far from being exclusively due to a few sagacious men of old, they are the natural and necessary results of human organization. Man, as well as the lower tribes, has natural arts belonging to his species.

Once introduced into the hut, fire came under the management of females, and wrought a revolution in previous habits. Food was no longer consumed without cooking; roots as well as flesh were roasted; subsequently, victuals were boiled, and the phenomena of ebullition, hot water, and steam observed. Culinary utensils were devised; rude seats, tables, and beds made their appearance. Natural vessels were superseded by artificial ones; earthenware caldrons succeeded those formed of skins, of the calabash, and joints of bamboo. Spinning, weaving, and knitting stepped in; and the comforts of a permanent habitation put an end to the miseries of roving the forests without dwellings or dress. Before these things were accomplished, man could have had but faint views of his destiny, none of the glory that awaited his posterity.

It may truly be said, that the phœnix of the arts arose from the ashes of the domestic hearth, and that from it the first rays of science shot forth. Then who can reflect, without admiration, on the numerous sources of artificial light, by which social communion, and the great work of domestic and professional fabrication, is continued after the going down of the sun! To the vegetable oils, resins, tallows, sperm, lard, &c., we are indebted for the multiplied myriads of tapers that are kindled every evening, and around which social parties are everywhere employed, and cheerfully employed, in modelling and adorning rude matter. In warm climates, the candle or lamp is as indispensable as the stove or grate in cold ones ; and, in all lands, what would the condition of the sick and dying be, were it not for light to assist them in midnight hours ! A condition so distressing, that imagination cannot exaggerate it ! Humanity cannot be represented in a lower depth of degradation, than when pictured without the tinder-box or its congeners.

Fire gives us what Eden had not. If a flaming sword drove one man out, the knowledge of flame has put within the reach of all men blessings unknown there.

The adaptations of things in the matter of fire, with a view to keep it in human hands, small as they seem, have a bearing on the general economy of the world. The conditions necessary to the evolution of a spark by friction, and to nourish it into flame, are such, we all perceive, as serve to prevent any serious results from natural abrasions. Had the necessary amount or intensity of friction been double what it is, man had made little use of fire to this day. We do not see how, in the first ages, he could have procured it at all, nor yet in subsequent days unless an advance in the arts supplied him with better means. Yet, how the arts could exist, much less be advanced, without fire, it would be hard to tell. At all events, sparks could not have been drawn out of wood by individual exertion without mechanism, and what mechanism did the pure savage possess, or could he, without fire, possess ?

Had the requisite amount of friction been less than it is, we might have scarcely known wood as a fuel or in the arts, since Nature might then have acted the part of an incendiary, and fired it as fast as it grew. And why, it may be asked, do not gales of wind now produce conflagration? Because the required rapidity and intensity of friction at *one point* are not continued there, till hot, abraded dust is sufficiently collected to receive the spark. The verge of danger is approached nearer in hot than in cold climates; and yet we find that where vegetation is parched like stubble, the air glowing as in an oven, resins oozing out of some trees, and heat and inflammability impressed on all, the violent collision of trees with trees and stems with stems, inflames neither the reed swamps of India, the corn brakes of America, the pitch pines of the North, nor the unctuous boles of equinoctial regions: —so admirable and nice are the adjustments that prevent, in such cases, ignition.

If it were not for these, the world would be in constant danger: the larger animals would leave tracks of smoke and ashes behind them; the tread of an elephant or buffalo's foot on dry reeds and grass, or the rushing of their bodies through jungles, would fire them. Were the amount of friction required to produce fire less than it is, excessive care would be indispensable in thrashing and stacking grain, carting timber, and even in working it. The mere opening of a set of drawers might endanger a bureau, while a straining ship would wrest a spirit out of her groaning frame more to be dreaded than the element she tossed on. Indeed, as things are, the line between artificial attrition that produces fire and natural attrition that does not, is so fine as to excite wonder that a barrier so frail should be so powerful in preventing conflagrations.

But the adaptations and adjustments of every thing in this wonderful workshop to the work, are everywhere, and abound where least suspected. What a volume will some Humboldt of the arts one day write on them!

Means to produce fire were not to be confined to laborious attrition of wood. As all arts were to advance, so this also, meagre as it might be supposed in variety of resource. Tinder was early kindled by sparks struck out of certain stones, which, however, were not universally used, because not everywhere found. Neoptolemus observed in the cave of Philoctetes a few rags, a rough drinking vessel, and some flints. This ancient Crusoe, in reciting his miseries, says he had had no fire; "but rubbing flint on flint, hardly did I elicit the hidden light!" *

Flints contain sulphur, detected by the odor when two are struck together. Sparks are given out by quartz, also by the cane or Indian reed when struck, probably from the silex they secrete.

Hearne, in journeying to the Northern Ocean in 1772, discovered a solitary female of the Dog-ribbed Indians, who had been seven months in the forests without seeing a human being. To support herself she had built a hut, and with much ingenuity snared rabbits and partridges, &c. To procure fire she picked up two sulphurous stones, from which, by long friction and hard knockings, she drew sparks, and used touchwood for tinder. Though acquainted, as she must have been, with the process of obtaining fire from wood, she probably found herself for want of practice unable successfully to perform it.

Botturini says the ancient Mexicans occasionally drew

* Tragedies of Sophocles, literally translated.

fire from flints; they are not known to have had iron, but they had iron stone, which they used for the purpose. The Patagonians pursued the same process. Samiento, in 1580, met with Indians in the Straits of Magalhaen, who struck fire with flint and a piece of metallic earth. They used feathers for tinder. The Arctic Indians have two ways of obtaining light, "one by rubbing two sticks, the other by knocking together two stones, and catching the sparks on dry moss."

These examples, among a host, may suffice to show by what steps the second great device for obtaining fire was reached. The flint and steel, or tinder-box, not only economized time and labor, but introduced an epoch vastly in advance of that represented by friction sticks. It marked the conquest of iron, and the consequent emergement of man from the forest. The blacksmith's forge had then been put up. The date of the tinder-box is as much unknown as its contriver. Mythology ascribes it naturally enough to workers in iron—to Vulcan, and also to the Cyclops. Long and prosperous has been its career; it has come down to us improved by the ingenuity of men of all nations, but its days are ended. It has fulfilled its mission and retires, being succeeded by the friction-match, a device as much superior to it as it was to its predecessor. Its departure is characterized too by the opening of a new cycle in the arts—one eclipsing in glory all other cycles.

Sparks drawn from flint and steel excite no curiosity, but they are interesting phenomena. Received on a sheet of paper they are found to be globules of vitrified metal, each being separated by the flint, fused by the heat elicited by collision, and oxidized by contact with the air as they fall, just as fine filings are melted when dropped through the flame of a candle. Strange, that while man is ignorant of the metals, he can draw fire out of wood; and when he subdues them, he extracts it more copiously and readily from cold iron itself. Who can fathom or even imagine the resources of the arts that yet lie hidden in matter!

Steel gives out more sparks than iron. Reaumur found a composition of two parts of iron and one of antimony supplied more and larger sparks than the best steel. While this alloy was being dressed in a vice a train of fire followed the file.

There have been till of late days two general modes of producing fire. Each represents a certain condition of the arts, and both embrace the entire cycle of human existence to the present century. The friction-match is the third device: its career is but beginning.

Fire and fuel having been provided, means for obtaining a wide range of temperatures were required. Without devices for increasing and modifying the intensity of heat few of the metals, and especially the chief of them, could ever be reduced. These were within man's reach, but he was to develope them himself. Of blast furnaces he had many hints in the influence of wind on flames, and in the action of his breath on the coals on his hearth. Every savage thus urges his smouldering fires, and as he progresses, employs reeds for blowing tubes. With such, Asiatic and African smiths still fuse metal. Rude bellows, as substitutes for the lungs, followed; and at length draught-furnaces were found out, and continue still to be improved.

CHAPTER V.

THE THREE STOREHOUSES OF MATTER.

1. MINERALS.

LET us now glance at the three great departments of matter, in the order in which they appeared, and see how each furnishes a peculiar class of contributions to the factory; or rather how the mineral, vegetable, and animal kingdoms, as they have been named, are veritable laboratories and storehouses of materials for human manufactures. This is rigidly and to the letter true; for there is not a substance, force, or motion in one of them, be it what it may, that does not reflect light on the earth as a workshop, and on man as an artificer. We can refer only to a few items in each department; but they will serve as specimens of the multitudes, seen and unseen, that crowd around us. To some thoughts on the first, or MINERAL division, let us devote the present chapter.

If subterrene materials are to go through man's hands, are they offered to him in such forms and conditions as to be manageable? Yes; and remarkable are the discriminations in this respect. Those that are easily dug into are homogeneous, and extend over large areas, as fields of clay, coal, sand, marl. So also with such as can be quarried, as rocks; they are in immense and continuous masses, from which blocks of any required dimensions may be taken—monolithic temples have been dislodged. But how is it with the metals? Suppose they had been laid up in solid mountain piles like granite, or in continuous pure and thick strata, what could have been done with them? Nothing. It would have been beyond human power to have extracted a supply from them. Had a mammoth boulder of the finest malleable iron been placed at the birth of man in the centre of every township for the use of its inhabitants, all would have remained undiminished to this day. Like blocks of copper recently found in ancient diggings on Lake Superior, from which Indians had endeavored to cut portions with flint tools, they would have remained monuments of tantalism. With all the advantages of modern arts, masses of native copper present serious difficulties in the way of their reduction into manageable masses, say of a ton or two. In the Lake Superior mines the present method is to cut grooves with chisels entirely through the blocks. Twelve thousand dollars were thus expended on a single block.

In New Mexico meteoric masses of fine malleable iron frequently occur. For centuries some have been used as town anvils. At Tuscan in Sonora, Mr. Bartlett, late commissioner to determine the boundary line between the United States and Mexico, heard of one weighing about 600 pounds, and serving as an anvil in the blacksmith's shop. Desirous of obtaining a specimen, Mr. Bartlett observes it was with much difficulty that a small fragment, only sufficient for an analysis, was detached. At the Hacienda da Concepcion, in Chihuahua, he found another weighing between three and four thousand pounds, and such, he says, was the tenacity and hardness of the metal that, after an hour's incessant labor and the breakage of five chisels—all his company possessed—they only succeeded in detaching three or four pieces that did not weigh an ounce altogether. An attempt had once been made to reduce the mass by building a fire round it, and heating it to a white heat; but the workmen could not then approach it, and their labor was lost. The expense of the operation exceeded one hundred dollars, and the only result was a piece of metal large enough to be worked into a pair of spurs.*

Thus, where the metal has been of the first necessity since the conquest, and more precious than gold, the people have brought it, and still bring it, from a distance of a thousand miles overland, because of their inability to take what they require from these moderate-sized lumps at their very doors.

Without reflection, we might have thought it preferable to have metals thus provided, and pure without the trouble of smelting them; but the Proprietor knew better, and hence, happily for us, they seldom occur except as minerals that readily yield to the pick, while iron, the chief of them, is only found in ores. Even the softer metals, as lead and tin, would have presented difficulties in solid strata far surpassing all that attend their quarrying and reduction. Their very softness and inelasticity would have been exceedingly embarrassing to miners of them, whereas, found as they and others are, they are

* Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, &c. By John Russell Bartlett. New York: 1854.

obtained and passed through the furnace without embarrassment.

But while iron is the most important of metals, it is the most difficult to reduce to a malleable state; so that man was not to have it without a corresponding outlay of mental and physical exertion, that he might appreciate it the more. Still, every aid consistent with the prime design of his education as an artificer was given him. Thus, how pregnant with meaning is the fact that iron is generally found stored with fuel to reduce it! English writers proclaim it as the chief cause of the development of the iron trade in Great Britain, that the ore occurs among the coal-measures, "so that the ore and coal for smelting it are found in the same spot; while not unfrequently the coal-measures contain the refractory clay used in the construction of the smelting furnaces, and the limestone needed as a flux occurs at no great distance."*

If man was to be pre-eminently a manufacturer, a suitable material for cutting-tools was of paramount importance. The agent of all arts, it would be among the first and last of his requirements. We know that iron is that material. In reference to it, a question arises, which, though now of little moment, would be a serious one if the metal had only just been discovered. It is this:—If the substance be intended to cut all others, how is it to be cut? How formed into tools without the aid of still harder tools? Let it be remembered that before these queries were practically answered, the idea of giving to natural bodies qualities they did not already possess had

* Report of the juries of the London Exhibition of 1851.

not entered the minds of men. Had mines of steel and adamant been provided specially for tools, the same difficulty would have occurred; for tools of still harder materials would have been necessary to shape and sharpen them. While, therefore, a metal sufficiently indurate to carve, cut, drill, and plane others was of the first necessity, it was not provided by nature, because it would have been useless unless furnished in the form of finished tools. Now the way in which this most interesting exigence was met excites, what every mechanical resource in nature excites when first taken cognizance of, unmingled surprise and pleasure. Iron was made capable of being *artificially hardened*, and thereby of being made into implements that forge, file, saw, and cut even iron itself as easily almost as soft lead or tin. The grand secret of converting iron into steel opened an ocean of new ideas on the arts. It was an early discovery, but second in importance to none. Steel is emphatically the master metal.

Iron is more in demand than other metals, while its applications are being rapidly multiplied, some of them involving vast additions to its yearly consumption. Now what is the amount of the stock in view of such drainings? Just what might be supposed. The metal abounds more than any other, and apparently more than all others put together, and it abounds everywhere. The quantities now annually raised, immense as they are, will in another century or two be deemed trifles.

In France, the consumption of iron is set down at about 80,000,000 of kilogrammes. In the United States, there were raised in 1850, 1,579,309 tons of iron ore; but it is in small countries, as England and Belgium, that the riches of the earth's cellars in this and other materials better appear. In the island of Great Britain, the product of iron ore in 1848 was over two millions of tons of metal; in 1853, two and a half millions; upon which, as pig and bar iron, were expended over ten and a half million tons of coal. This enormous amount of one metal is not to be taken as the yield of the whole island, but only of a few spots, which bear no greater proportion to it than it bears to the rest of the world. Indeed, all the mines opened on the face of the earth amount merely to a few borings, from which samples only have been extracted.

The lead ore raised in England in 1852 was 91,198 tons, which produced 64,961 tons of metal. Of tin, the average produce is 5,000 tons of metal; of copper, 11,776 tons of metal, in 1852. The annual product of the East India tin mines is estimated at 53,000 piculs [McCulloch.] Besides her home consumption, England exported in 1841, 690,000 cwts., or 38,000 tons of hardware, cutlery, steel, silver, gold and plated wares, tin plate, pewter and brass ware. The value, 33,000,000 of dollars. The amounts were nearly doubled in 1852.

In the three principal mints of the world there was coined in pounds sterling, in 1853:

	Gold.	Silver.	Copper.	Total.
United States, . .	10,377,776	1,570,514	13,412	11,901,702
England, ...	11,952,391	704,544	9,073	12,666,902
France, ...	13,218,536	803,588	78,996	14,101,180

The total amount of coin of all kinds coined during the year in the three mints was £38,728,830, which consisted of no fewer than 174,448,021 pieces; or in American money, the total coinage of the three mints was 193,644,150 dollars.

There is no need to enumerate the metals or their diverse properties; but one particular may be adverted to, though it is merely one of ten thousand confirmations of a general truth, viz. that as the arts advance, and new materials are required, they will be forthcoming; or else the desired qualities will be found in old materials. Examples are not uncommon in both particulars. As regards the former, caoutchouc and gutta-percha are quite modern instances from the vegetable kingdom; and what are the facts as respects the metals? The ancients are supposed to have known only the seven principal ones: gold, silver, copper, iron, mercury, lead, and tin. In the dark ages of inactivity that followed, the number continued the same. In the fifteenth and sixteenth centuries modern inquiries began, and antimony, bismuth, and zinc were added to the list; in the eighteenth century platina, nickel, arsenic, cobalt, and seven or eight others; and in the present century some twenty more.

Among these last is aluminum, a white metal resembling silver, which fuses at about the same temperature, ductile, exceedingly tenacious, light as glass, and not tarnished by exposure. In time, beds of clay (its ores) will be converted into it. In many arts a new metal is much wanted. For suspension bridges, a wire whose tenacity exceeds that of iron, much lighter, and not subject to rust, is now a desideratum. Aluminum offers some of these advantages, if not all of them. But there are others. From M. Vertheim's experiments on wires of equal diameter, made of iron, of nickel, and of cobalt, it appears that the weights which determine the rupture of these several wires are respectively as the numbers 60 for iron, 90 for nickel, and 115 for cobalt. This would establish for cobalt a degree of tenacity almost double that of iron. Moreover, nickel and cobalt are worked at the forge with the same facility as iron. They are perhaps less subject to oxidation than iron, and may be used for the same purposes.

From recent experiments of M. Deville, laid before the Academy of Sciences of Paris, it would seem that aluminum is soon to be given to the arts and to commerce. Common clay, so abundantly spread over the whole earth, yields 25 per cent. of its weight of metal. Medals have been struck in aluminum. It is represented as inoxidizable as silver, and a much better conductor of electricity than iron.

We can, indeed, form but imperfect ideas of coming changes in engineering by fresh accessions of metals, and in all arts by new materials and new combinations of them. The metallic alloys, now so few, will become a multitude. The great fact that different bodies coalesce in various proportions, and form compounds with properties not possessed by the originals, but eminently serviceable, elicits little remark; yet it is in every point of view a remarkable one. Nature did not prepare for us such alloys as brass, bell-metal, pewter, and a score of others indispensable; but she gave us the materials and the power to produce them.

From the poverty of language or paucity of ideas, we are accustomed to speak of the comparative values of natural productions; yet it is hardly correct, for they are all so allied to each other, that not one could be what it is without the rest. But for this suggestion, we were about to represent as next in worth to the metals the earths from which come bricks, tiles, domestic earthenware, and all the fertile varieties of ceramic manufactures, so influential have such things been in multiplying human enjoyments. This is perceived by comparing the few rude attempts at pottery of primitive tribes with the general profusion of porcelains at the present day; and yet that is but noting one item in a volume of items. Glass, the most beautiful of compounds, is another; and the field of industrial enterprise it has opened has certainly not been half gone over. That the ingredients of this artificial metal should be in such plenty, so close at hand, the process of producing and working it so easy, and that it should prove of transcendent utility to science as well as to social progress, may be received as indications of equally novel and attractive alloys yet to be found out for new branches of trade and commerce.

One of the earliest and most obvious of arts, the working of clays, prepared man to grapple with indurate bodies. With the metals he could have done little or nothing till he had furnaces, crucibles, and retorts. It may serve to assist the mind in trying to grasp the amount of plastic matter annually drawn out of the earth and worked up by man, to note a few items. There were made in England, in 1847, 2,193,829,491 building bricks, of all sizes. Allowing eighteen to the cubic foot, they were sufficient to build a solid column one hundred feet square and over two and a quarter miles high. The clays worked into paving, roofing and encaustic tiles, draining and other pipes, works in terra-cotta and architectural decorations, into fire-bricks, grate-backs, furnace linings, gas retorts, chemical apparatus, and numerous other goods, in clays and cements, would suffice for another; while a third might be reared from the materials worked into pottery, stone-wares, china, glass, and mineral fabrics not enumerated above. Then how greatly the number might be increased by the rocks quarried for building and engineering purposes! Amid the variegated shafts that might thus be yearly raised on the soil of England, those of coal would be conspicuous for their number and for their color, since they would be relieved by those of marble and chalk.

Suppose all the metals and minerals drawn out of English ground the last fifty years were thus disposed of, what a striking illustration they would furnish of the treasures stored away in the lower stories of this Earthly Factory! But what are fifty years of the past to the decades of centuries to come, when the whole globe might be more thickly dotted with such shafts!

The amounts of dressed and undressed granite, limestone, sandstone, flag-stones, slate and other rocks, drawn annually out of the earth for the public and private works of nations, would tax our powers to calculate. It is, moreover, surprising how these amounts increase by new applications of the commonest of minerals; how slate, for example, is becoming a substitute for wood in floors, as well as in roofs; in panelling, steps of stairs, linings of rooms and cisterns; in household and even ornamental furniture; in sideboards, tables, chimney-pieces, &c.

Sawn, split, planed, carved, polished, and inlaid, it has already become an important element in the industry of some nations, and will become one in many. The same may be said of steatite or soap-stone. Then, how vast the quantities of the richest marbles, alabasters, porphyries, spars, serpentine, jasper, jet, &c., which are being constantly worked up in columns, friezes, sculptures, mosaics, and in every department of architectural and household carvings and statuary. The conclusion is irresistible, that these and other applications not yet found out, were contemplated by the Creator, and that for them the diverse properties, colors, textures, grain, and appearances were given to rocks and stones.

One thought more before we dismiss them : To iron, in one form or another, all solid bodies yield ; at the same time a power to act on it is deposited in the most refractory ; and hence when blunted, these, in the form of grindstones, whetstones, and hones, restore to its cutting edges both sharpness and polish. This reciprocal power between iron and the rocks may be considered—if considered at all—an incidental or small affair, and yet it is of essential value in the arts. What would cutlers or carpenters do without grindstones and hones, or millers without millstones ?

Everything that has been discovered about coal shows what it was intended for, and the importance attached to it by the Creator. Its formation began with the earliest land vegetation, that no time might be lost in its preparation, and the advent of man not be unnecessarily delayed.

The primitive or lowest rocks contain no traces of animals or plants, although some of them, as clay-slates, were deposited from water. Upon them repose certain others of vast thickness, in which vegetation first appears in sea-weed, accompanied with marine life in its lower forms. These rocks have been named the old Palæozoic rocks; and it is not till we ascend through other formations to the new Palæozoic period that land vegetation appears. Then, dense and matted forests covered all the land. The universal and singular character of the vegetation has been well ascertained. Its varieties were exceedingly limited. About two thirds of the species and four fifths of individual plants belonged to a single family of ferns; another group were club mosses; and a third the Equisetaceæ. These three families constituted three fourths of the vegetable world during the first coal period, and in that proportion contributed to make up the first coal fields of the earth.

The plants thus converted into a substance more valuable than diamonds, are now counted among the worthless. The first kind is represented in the dress of our heaths and moors; the second by plants which none notice but inquiring botanists; and the third, by what farmers call "horsetails," that grow in ditches and swamps, and are everywhere deemed signs of bad land. The three dwarf families were, however, giants in primeval forests; they there rose into trees, with trunks varying in height from ten to sixty or seventy feet. Having accomplished the task assigned them, they are probably now dying out.

Such was the monotonous and unattractive character of the oldest vegetation. It had no grass, nor succulent, crisp, or pulpy fruits; no flowers, no animals, and no birds to break the awful silence with their songs. The period was too early for them: food had not been prepared, the sweltering temperature was uncongenial, and the atmosphere thickened, if not darkened with vapors fatal to life. Still, everything was just what was required to accomplish the objects of the epoch.

We have no data for measuring the period during which the vitality of the earth was thus being concentrated; and if we had, our minds are hardly prepared to receive the results, so minute and contracted have been popular and authorized speculations on the subject. But let no one imagine it was prolonged unnecessarily or unprofitably for a day.

Nor let any one surmise that the then vegetable power was wasted in desert air. It has come down, and now circulates through our vastly more varied and richer flora. There was no human eye to glance at or roam through the primeval forest; but every person now can have tons of its fossilized timber, and draw from it power expended on its growth. In the vast duration of the silent ages which constituted the coal-formations, the intention of the Creator is apparent in laying up a material that, in the remote future, was to give unprecedented animation and activity to the planet.

The first vegetation grew rank, and, as it ripened, much of it appears to have sunk, as in peat bogs, for trunks are found in perpendicular positions. Then a new geological period brought over the whole a platen of rock, and thus closed up the products of the first carboniferous epoch, preparatory to their undergoing the requisite pressure to fossilize them. But the first was not sufficient, hence successive alternations of rock and mineralized forests occur. Is it asked, why not have prepared the whole at once? Because, among other obvious advantages, time was saved by the plan adopted, *i. e.* by sealing up the proceeds of the first formation, and passing them on towards the final process of elaboration, while material for new charges, or beds, was being accumulated. These kept compressing the lowest one into smaller and smaller space, which they could not have done except by the interposition of the rocky platens. In this way the first layer would be ready for man, while the others were, in their order, maturing for him.

Thus were all the fields of mineralized vegetation under our feet prepared. The interposition of platens of rocks, besides being necessary in the process of pressure, was also required to keep out other matters. Had coal been mixed up with other substances, its value had been greatly diminished; but special care has been taken to preserve it from adulteration. This feature in its history is as interesting as any other.

The prodigious pressure to which the strata were, and are submitted, increases as they settle down, and thus the platens are brought nearer and nearer, as the material between them is compressed into less and less space. The pressure, combined with internal heat, is considered sufficient to account for the carbonization of both bituminous and anthracite coal. The latter is the densest, and is deemed to belong to the oldest formation.

Leaves, twigs, branches, and trunks grew much as now they grow, *i. e.* not faster than they ripen in the tropics; yet, if we examine American forests in the torrid zone, no recognisable addition to vegetable remains is perceptible since the discovery. No doubt large quantities have been swept down and buried at the mouths of the Mississippi, St. Lawrence, the Amazon, Oronoco, and La Plata, for ages, and also by all the large streams of the Eastern hemisphere, during the historic period. But, supposing the materials of the early coal strata were thus collected, which is hardly reconcilable with their purity, or allowing, which is more probable, that they sank in bogs where they sprang up, still they matured not much, if any, faster than now.

In upper beds of coal new systems of vegetation appear. Pines, palms, firs, maples, and poplars, are common; and in them are intimations that, compared with the duration of the coal periods, the historic epoch of forty centuries is but as an hour. "A fossil trunk was found in an upright position, measuring eleven feet in diameter, and in which 729 annual rings were counted. This gives us a striking illustration of the vast periods of time which have passed by on earth; and although chemistry is capable of strengthening and concentrating active forms in high degrees, and although this magical science can often bring about in a few minutes things that require many years to effect in the ordinary course of nature, the contemplation of the enormous sum of years of past times warns us not thoughtlessly to over-estimate the experiments of the laboratory, when we are investigating great geological phenomena; for by continued action through thousands of years, very weak agents are capable of producing results which at first sight we should imagine to be impossible."—*Von Kobel.*

The annual yield of the English mines has risen to 34,600,000 tons. This enormous drain has led to inquiries respecting the future: some writers predict exhaustion within a few centuries, others contend that nothing of the kind is inferable, even with a continuously increased demand. In South Wales are stores not opened. They have been examined and are found to extend over an area of about 12,000 square miles, and they alone could meet the demand after all the present English coal mines are worked out. In the United States over 150,000 square miles of coal beds have been ascertained already—of these upwards of 40,000 are in Illinois.

A first element of progress for all time, it is preposterous to suppose the supplies of coal can ever be exhausted or even become scarce. The idea is almost blasphemous. It is a reflection on the Proprietor of the earth, and can only arise from not knowing the manufacturing character he has stamped upon it: though invisible in manufactures, the presence of coal—that is, its power—is in almost every thing man makes, from a needle or penknife to a steamship; from a brick to a city; a ball of thread to anything made of thread.

In nothing are the manufacturing purposes of the Creator more obvious than in the article of fuel. Of what value indeed could metallic ores and soft earths have been without it. To meet the constant demand, wood, peat, turf, and other inflammable materials, are spread over the earth's surface, while its interior is surcharged with coal. It is a magazine of fuel and of materials to be heated. As long as it remains a factory, coal must be provided, and will be. There is reason to believe that the formation of this substance is now going on in the depths of our oceans—preparing a supply for workmen under new configurations of the surface. There is indeed nothing to indicate that the elaboration of matter here is to stop. We cannot imagine it to cease on any inhabited orb. That the physical aspects and condition of the earth are ever changing is certain; and from the fact that, with the whole heavens, she is ever varying her position in space, it may well be that future mutations will exceed those she has undergone.

But change implies not decay. It is the antagonist of stillness, the preventive of stagnation, the conservative result of the ever acting forces in matter; hence, not a plant, a pebble, a world, or the universe of worlds, can remain for two moments absolutely without change. It is thus that an endless succession of varieties in the forms and qualities of matter, with corresponding modifications of artificial fabrics, are secured. As the earth's forms and products vary, so will human arts. Perpetual vigor circulates through all matter; and the earth, we may presume, has within herself the elements of lasting duration. Therein lies the difference between God's mechanisms and ours. Could we implant enduring energy within, or cause it to circulate through them, we should rival him in power.

The mineral kingdom furnishes raw material for human labor: the production of food belongs not to it; and yet it supplies that which gives to food its best relish. Salt, next to bread, is a necessary of life; and as the common seasoner and great preserver of food, it is quarried as a mineral in most countries. The mines of England have long been worked, and some are among the richest yet discovered. The consumption of salt in Great Britain is estimated at 616,000,000 lbs. Counting 22 lbs. for each individual, and assuming this as a fair allowance for the world's consumption—and we should suppose it under rather than over the truth, since there are immense quantities consumed by cattle, and more still in various manufactures and arts not included—then the thousand millions of human beings require an annual supply of twenty-two thousand millions of pounds. A better illustration of the profusion of man's kitchen supplies could hardly be cited than these eleven millions of tons of one condiment.

In warm climates, the sea is a magazine of salt, the water being evaporated in wide basins, formed in the soil. That little Atlantic patch, known as Turk's Island, furnishes about 50,000 bushels of sea salt weekly. Salt springs are also more or less common in all countries. Were it required to quote particulars respecting the sources of rock salt, we might refer to one bed of it in Gallicia, which is 460 miles long, 90 miles wide, and 1200 feet thick.

CHAPTER VI.

THE THREE STOREHOUSES OF MATTER.

2. VEGETABLE PRODUCTS.

THE factory would have been a failure if its operatives had had only minerals to work in. Properties not found in them were a necessity; and unless substances possessing them were to be had, the work would stop. The VEGETABLE department, by its contributions, prevented that. One prime desideratum was realized in the various kinds of wood—a species of matter eliminated by different processes than minerals, but one that added to their value by facilitating the means to procure and employ them.

Now, as wood could not be produced under ground, and as, if it were developed like minerals in strata or wide layers, there was not room for it upon the ground, what was to be done? What would have been our suggestions on the dilemma? The needful quantity was so large that, if trees had grown horizontally, the earth had long ere now put on the appearance of a spherical raft of closely interlaced timber, floating in space as if for a market. There had been no room for man nor for his operations; and yet he requires almost the whole. Observe, then, with what singular wisdom and economy the exigence was met, and only a moderate, indeed a very small space, taken up. The new material was made to rise in vertical columns, whose lower ends only occupied the ground, all the rest being above, where there was nothing to interfere with or be incommoded by its extension; the intermediate spaces on the ground being, moreover, as usefully occupied as if the boles of trees had not interrupted them.

Another point of economy is exhibited in the general form of boles of trees. Their sections are circles; hence the greatest possible quantity of timber is compressed into the least possible space. Had they grown up in wide slabs, in square or angular masses, the same quantity of material would have taken up a great deal more space, and would in other respects have been inconvenient. They would have been less able to resist storms of wind, and would have seriously interrupted the flight of animals through forests. Does the reader think there was abundance of room, and therefore no need of contrivances to make the most of it? Let us look at it: More than two thirds of the earth's surface are covered by oceans, seas, lakes, rivers, and other bodies of water—sources and distributing reservoirs of moisture and fertility, and at the same time theatres of aqueous and sub-aqueous life. Less than one third, then, only is left (and in it are included immense deserts of sand, wide regions of barren rocks, extensive moors, and arid wastes) for the swarming myriads of animals for which it has to provide room and food; for the moving millions of men, and their dwellings, farms, cities, factories, roads, and all other undertakings requiring room; for vegetable products required in a thousand manufactures, &c.; and the wonder will be how such masses of material are raised, and such inconceivable legions of living beings accommodated, on so small an area. Moreover, it is not merely what has been and is now required, but what will be when our species, instead of numbering one thousand, will amount to three, and perhaps to five thousand millions.

It would be superfluous to remark that woods most useful most abound, and that every climate has those most durable in it; nor need reference be made to the functions this glorious material fulfils; that to it we are indebted for social, civil, and manufacturing architecture; for navigation and its wondrous appurtenances; for implements and mechanisms without number; and for some of the most salutary and refining influences that pervade society.

As in the case of the metals, timber is provided in manageable masses. The size of trees is adapted for human not Cyclopean artisans. Had they generally approached in dimensions the great Californian cedar—325 feet high and 92 feet in circumference at the ground; 88 feet at four feet, and 66 feet at ten feet above the ground—what could have been done with them—with logs, one of which laid along the pavement of some streets, would fill them to the roofs of three-story houses! The difficulties of felling, transporting, handling, and slitting such into beams and boards, would have been seriously embarrassing.

The adaptation of the size of trees to human strength and means is exemplified in the annexed table of the ordinary dimensions of full-grown boles of Europe, prepared by Boussingault. (See his "Rural Economy.")

Names of Trees.	Usual Height of Trunks in Feet.	Usual Diameter of Trunks in Inches.
Spruce Fir, . .	26 to 100 feet	47.1 inches.
Larch, . . .	26 " 100 "	39.3 "
Poplar, . . .	19 " 65 "	31.8 "
Pine, . . .	16 " 65 "	34.1 "
Plane, . . .	16 " 48 "	36.1 "
Oak, . . .	" " " "	31.4 "
Elm, . . .	" " " "	31.4 "
Birch, . . .	" " " "	29.4 "
Beech, . . .	" " " "	28.2 "
Lime, . . .	" " " "	25.9 "
Ash, . . .	" " " "	23.5 "
Willow, . . .	" " " "	11.7 "
Chestnut, . . .	13 " 48 "	36.1 "
do. another variety,	" " " "	28.2 "
Maple, . . .	10 " 48 "	" "
Service, . . .	13 " 39 "	17.6 "
Acacia, . . .	13 " 26 "	19.2 "
Hornbeam, . .	10 " 23 "	21.2 "
Mulberry, . .	" " " "	16.5 "
Wild Pear, . .	" " " "	14.1 "
Crab, . . .	6 " 20 "	12.9 "
Walnut, . . .	6 " 16 "	36.1 "

These measures are those of the trees at their maturity, and fit for felling. The spruce and larch present the largest boles, but even they do not exceed four feet in diameter. Next are the plane, pine, oak, elm, chestnut, and maple. The walnut exceeds most of them in growth, but attains only one third of the length of many.

If the average dimensions of European trunks were deduced from the preceding table, it would, we should suppose, be much too high—about 32 feet in length and 27 inches in diameter. The medium in the virgin forests of both Americas, where magnificent boles abound, and where for decades of centuries they have been undisturbed by man, would hardly come up to it. In the forests of the United States and Canada we should think 15 inches would be a fair average diameter, and 18 inches a liberal one. Here we have the button-wood tree among the largest; then the white-oak, whose stems run up 80 and often to 100 feet, with a girth at two feet above the ground of 15 feet; white-wood—tulip tree or yellow poplar—that furnishes carpenters with their widest panelling; black walnut; white and pitch pines, and elms that rival them; hemlock, chestnuts, maples, lime or basswood, red oaks, hickory, locust, ash, dog-wood, magnolias, &c.

In most of these, examples of extraordinary dimensions and age occur, as they occur everywhere; but such are no more to be taken as data for the general growth of trees than individuals standing like Maximus, eight feet high; and others who live 150 years, as standards by which to determine the stature and age of man. Trees grow up and die like men. Experienced lumberers tell at a glance when they are ripe; that is, when they will acquire no more sound wood. After that, they may swell, like mortals in a dropsy, but not in health and solidity; hence trees, like animals, attain determined dimensions, and then cease to increase in any one direction, except at the expense of another. Gigantic trees are almost always hollow. Emigrants' wagons are often backed into the interior of ancient button-woods. The great dragon tree of the Canaries, 16 feet in diameter, was as thick and hollow in A.D. 1402 as it is now. The largest European oak (in France) is 23 feet diameter, but within the trunk is a natural chamber, over 10 feet one way and 12 another. Besides the mammoth tree of California, already mentioned, there are others in Oregon and California of the same kind; some even larger, but not sound. One offers a more commodious room than many miners' lodges. Of some blown down, a gentleman rode his horse through one, from end to end; another is mentioned 110 feet in circumference and 410 feet in length. This, too, is hollow; and if the hollow was a little enlarged it would make a very good rope-walk.

Admitting the primitive forests of tropical America to be richer in gigantic trunks than the northern half of the Continent—a fact by no means certain—it is, I think, doubtful whether they would furnish an average thickness of 20 inches in their boles. The mahogany tree is the most remarkable for its magnitude, and yet the largest recorded log was only 17 feet long by 54 and 64 inches. In the public and private buildings of South America, timber of unusual dimensions is not met with. Wide flooring planks occur in Brazilian cities, the wood resembling in color and texture soft mahogany; but I have rarely found them over 20 inches, and the greater part within that width. The widest planks to be met with in the Atlantic cities are in the boxes in which sugar comes in from the interior, viz. from 2½ to 3 feet. The tree that furnishes them is the jequitaba, one of the largest of Brazilian trees. The wood is white, soft, and light, something like our white-wood. The natives made and make canoes of it, and in them its largest masses are to be seen. Five or six feet in diameter are probably the limits of its healthy growth.

I heard of the most extraordinary one on the upper waters of the Macacu river, which runs into the bay of Rio Janeiro. It was said to surpass in magnitude all others in the province. It was a straight, slightly tapering shaft, clear of branches and foliage for 100 feet up. Near the ground it was 32 feet in circumference, and three feet above the ground 27 feet. Its roots at one part presented the appearance of a range of vertical wall or rock, and 50 paces from the trunk they appeared half out of the ground, in long masses, 2½ and even 3 feet in diameter. A few feet above the ground there was a handsomely formed round hole in the trunk, naturally formed, and through it I pushed a stick in a horizontal position, seven feet, so that the stately trunk was hollow—a mere tube, whose walls were so thin as to cause surprise at their stability. A few years more, and it will be prostrated by age and decay.

Another feature in the world's timber is—the heaviest woods are not found in the largest boles, but generally in the smallest, a provision that vastly facilitates man's control over them. Fir is only half as heavy as oak, while ebony, lignum-vitæ, and box are rather shrubs than trees. Hickory is rarely seen a foot in diameter, and exceedingly few sticks of rose-wood are met with so large. The gigantic button-wood weighs only 26 lbs. to the cubic foot, the poplar hardly 20, the huge cypress 22, yellow pine 22, spruce and hemlock 23, white-wood 24, titan cedars 26, chestnut 26, maple 36, hickory 49, dog-wood 47, black-walnut 28, locust 40, ash 30, pitch-pine 32, elm 38, white oak 53, live oak 56, lignum-vitæ 71. The oak, from the large size it acquires, seems to be a special exception, in favor of the great marine purposes to which it it applied—like the blue-gum tree of Van Diemen's land and the teak of India, though the latter is not a heavy wood. It varies from 32 to 37 lbs. per cubic foot. Ceylon teak is the heaviest, being 42 lbs. The best English oak is only 39 lbs.

Thus the general truth remains that the largest trees are light and easily worked. The acacia is one of Asia's towering boles, but it weighs only 23 lbs. to the cubic foot. The great firs of Europe only 17 lbs. But it may be said—How is it when from trees of the largest girth some of the hardest timber is derived? Why then the boles are decidedly shortened. Thus in the account of the woods of Africa in the report of the juries of the London exhibition, the iron-wood tree, it is said, acquires a diameter of four feet, but the height of the trunk varies between 25 and 45 feet. The blaauw-bosch attains to eight or nine feet in diameter: as the wood is hard and heavy, masts of it from 200 to 300 feet long would be all but unmanageable; but what is their height? It varies between five and twelve feet! Another species has a diameter of seven feet, and the height of its bole confined to twelve, but more generally to ten feet? The boschquarry has a diameter of six feet ten inches, with a trunk six feet eight inches! Again, the seybast is seven feet nine inches in diameter, and in height seven feet ten inches.

The baobab, or monkey-bread tree, is among the most colossal of vegetable columns, but they are rather Doric than Corinthian in their proportions. In Senegambia trunks of great antiquity have been found from twenty to thirty feet in diameter, their heights not exceeding twice their thickness. One, thirty-two feet in diameter, is supposed to be from five to six thousand years old. Finally, yew trees are often of immense dimensions, but chiefly in their girth. The famous chestnut trees of Etna are so short that at a distance each has been taken for a group.

From what is at present known of the forests of the earth, this precious material is evidently prepared for us in masses perfectly within ordinary efforts and appliances to dispose of. Then, a perpetual supply is secured. Man cannot, if he would, waste his mineral stock; it costs too much to raise it to allow him to do that. But of timber and other vegetable products he might, through indolence and carelessness, bring about a scarcity; and so he would, were it not for the provision, that they have in themselves the elements of their preservation and multiplication. Acorns drop and take root without his care.

There appears an analogy between the life of man and that of shrubs and trees; at any rate, they shoot up, and ripen within such periods that human elaborators of one age cannot deprive those of another of timber, any more than they can of food.

Another fact:—Wood was to be more or less used as fuel over the whole globe. For this purpose no special varieties were required, since experiments show that the same weight of dry wood of every kind has the same amount of heating power.

In the wonderful compounds of matter that make up the second great division of material, how much there is to elicit and exhaust admiration. A new world of thought and of art was opened in wood simply: so different from minerals, in its being developed before our eyes, in the system of perpetuating its varieties, in the diverse magnitudes of trees and their variegated crowns of foliage; in the mechanical properties of the ligneous fibre; in its diverse degrees of hardness, softness, flexibility, elasticity, and texture; every feature offering a class of advantages in the arts: in its ornamental attributes, too, as exhibited in colors—jet in ebony, black and dark brown in walnuts and oaks, purple and light greens in the munjaddy and myle-ellah of India, red in mahogany and cedar; yellow in box, satin-wood, and the maples; then there is the red ebony of Australia, the cream-tinted and snow-white tulip tree, and every shade and tint in others. Moreover, how still more attractive are these colors made by straight, curved, waving, and involved graining! In addition to which, there is always more or less shading; and in cocoa and other rich woods are cloud-like dashes of India ink—some after the manner of tortoise-shell, and others resembling jaguars' and leopards' skins—invariably producing such pleasing effects that decorative artists incessantly labor to imitate them.

Then woods, besides furnishing examples of painting in colors, provide us with material for giving to other substances colors which they do not always themselves possess. Each pigment, too, besides imparting its every tint, contributes to develop other and very different colors. Logwood yields blacks and purples; fustic, olive-browns and yellows; barwood, camwood, Brazil, and sappan woods impart reds, blacks, and browns; woad and indigo, blues and greens; madder, the brilliant scarlet or turkey red; turmeric, bright yellows; orchil, purples, reds, and blues; annatto, orange; safflower, crimson, scarlet, rose-color, and pink. There is the green ebony, and a thousand more dyewoods, known and unknown.

From the same shelves in the vegetable storehouse we receive the great preservatives of colors, in the various lacs prepared from gums and resins.

Now, what is the language of these particulars, and of forest timber at large? That wood is specially designed for man—that no other occupant of the earth comprehends its worth, or can use it, or the lacs and dyes which it furnishes. Had it all been light and porous as the sycamore or cork tree, or, on the other hand, had it been heavy and dense as lignum-vitæ, it had been of comparative little value to man. But we are ordained to be elaborators in wood as in the metals; and hence the facilities for its acquisition, its varieties of masses, properties, and adaptations.

What proportion the amount of timber employed in the arts bears to that of mineral bodies has not, I suppose, been ascertained, perhaps not thought of. The beams, floors, partitions, stairs, window-frames, wainscotting, doors, roofing, and furniture, approach in bulk the material of the walls of most houses; but take the dwellings of man at large, and the greater part are built wholly of wood; add that which is consumed in them as fuel, and all the firewood used up in the earth's factories; then take into the account the timber worked up by ship-builders, carriage-makers, and other workmen in it: and the amount will equal, perhaps exceed, in cubic feet, all the materials drawn out of the earth. In any point of view the amount is extraordinary, and especially so, considering the very limited area of the earth's surface—a mere fraction—from which it is taken. But the secret is in its development: had it matured slowly, as minerals, not a ripe tree had been left standing, in the face of the enormous and incessant demand. How simply and beautifully are all difficulties arising from rapid demand met by rapid production. By this, supplies are secured, aud will be secured to artisans, although civilization levels, and will continue to level, so many forests.

Of the annual accounts of ship-building in the United States, the tonnage for 1852 amounted to 35,149.41 tons.

The lumber trade of a single town in the United States—Bangor, in Maine—amounted in 1853 to 182,942,284 cubic feet.

After timber was added to the artisan's stock, many chasms remained to be filled from the same department. One or two may be noticed. Wood and metals serve admirably to transmit force from one end of a bar to an object at the other, as in a crowbar or lever, the handle of a spade or a hammer; but in a wide class of cases it is necessary to send forces over distances, and in directions, where inflexible rods or shafts could not apply; as in hoisting a ship's sails or anchor, raising coal and ores from mines. A material, light, soft, pliable, tenacious, and easily handled, was wanted—*i. e.* a material for ropes; and how varied and inexhaustible the sources of supply are every one knows. Into few things was man more early initiated than in the use of ropes. Long before a tree was cut down he employed them. In tropical forests especially, natural ropes abound, everywhere pendent from the highest trees, and running along the ground, thousands of feet in length, uniform in thickness, and varying in dimensions from cables to whip-cord. The prosperity and progress of the arts depended, and depend no little on cordage: not by any conceivable possibility could they have come up to what they are had ropes and pulleys never been known.

Another primitive and permanent application of vegetable matter constitutes the world's wicker, basket, chip and straw-plaited wares; embracing agricultural and mechanical implements—*e. g.* the bodies of carts, the unique tepiti or mandioca press of the Caribs and of South American Indians; and an infinity of personal, social, and domestic articles and utensils. In the manufacture of straw-plait alone, seventy thousand persons find employment on one of the earth's small islands. 1,577 cwts. of plait were imported into England in 1852 for home consumption.

The vegetable world furnishes the most of our clothing The annual produce of thread is, in its lineal extent, all but inconceivable. 1,481,000,000—One billion four hundred and eighty-one millions of pounds of cotton were worked up into it in 1852. At the London Exhibition one manufacturer furnished samples of one pound of cotton spun into 900 hanks of 840 yards each, making nearly 430 miles. Another firm exhibited 4,200 hanks of the same numbers of yards each, making 2000 miles from a single pound of cotton! If we therefore multiply the above amount only by 430, the length of thread that a single crop of cotton could make, would be over six hundred billions of miles, or sufficient for a web of stout calico, a yard wide, and containing 85 threads to the inch, that would be more than enough to reach from us to the sun.

And yet all this is from cotton alone. Hemp and flax in some measure rival it: of them there were raised in the U. States in 1850, not less than 1,860,000,000 of pounds. In the rapidly increasing demand for material for woven fabrics and for machinery to manufacture it, but a few years would be required for our looms to fill an order for webs of double belting, sufficiently long to connect the Sun with each of the planets, in the way motion is communicated from the large drum of a factory to a number of smaller ones. We inclose our bodies in artificial cocoons:—In winter a lady is enwrapped in a hundred miles of thread; she throws over her shoulders from thirty to fifty in a shawl. A gentleman winds between three and four miles round his neck and uses four more in a pocket-handkerchief. At night he throws off his clothing and buries himself like a larva, in four or five hundred miles of convolved filaments.

Still, exceedingly few of the fibre-yielding plants have been taken up by manufacturers, and yet they abound everywhere—in weeds, sedges, coarse grasses, and in the leaves of some of the commonest shrubs and trees. The banana and its relatives have recently been named as examples, which besides fruit would yield from 9,000 to 12,000 lbs. per acre, of fibre, fit for fabrics of every degree of fineness, from muslin to ropes. Countless millions of tons of this and kindred substances spontaneously shoot up every year and sink again into the ground, neglected by man.

For her factories, England imported in 1851, 1,301,488 cwts. of hemp and 11,194,184 cwts. of flax = nearly 700,000 tons of 2000 lbs. each.

The flax and the cotton plant are not known to have flourished before the advent of man. Not till he came were they fully developed.

The very first of necessities is also supplied from this department. It is here that man's chief pantry as well as his wardrobe is placed. A description of aliments stored in it, their varieties, abundance, and means to improve them, cannot of course be attempted in these pages. Reference to some items will serve to show how liberally the Proprietor of the factory has victualled it. There were raised in 1850 in the U. States upwards of 592 million bushels of maize or Indian corn. Counting the bushel at 1¼ cubic feet, the grain would have filled a store-room, twenty feet wide, ten feet deep, and seven hundred miles in length. The yield of wheat in 1851 (125,607,000 bushels) would require an additional twenty miles to the structure; rye thirteen, buckwheat nine, barley four, between eight and nine for peas and beans, three or four for rice, and not less than five hundred for potatoes, beets, and other tubers. Partitions, miles apart, would be also required for apples, peaches, grapes, plums, cherries, and orchard produce; for sugar (over 200,000,000 lbs.), nuts, strawberries, gooseberries, currants; for peppers, mustard, spices, and condiments, and all the produce of market gardens, over a thousand miles more would be taken up—to say nothing of tanks for molasses, wines (in 1853, two millions of gallons), ale, cider, and other drinks. But figures soon lose their force on the mind, and it is the same with magnitudes when repeated. Besides, to acquire definite ideas of the riches of vegetation, definite quantities should be ascertained and considered in reference to the areas whence they are taken. When this is done with respect to every item in our world's delicious and plenteous bill of fare, torpid must be the souls that peruse it without emotions of admiration and gratitude.

Of tea, England imported in 1853, 66,360,555 lbs. Of coffee, the world's product is between three and four hundred thousand tons. The world's crop of sugar from cane, beet-root, and maples, cannot be less than 900,000 tons, since the amount recognised in commerce is 840,365 tons. The demand is rapidly swelling, but however much it may increase, there are no limits to the means of supply.

The bread boundary of the earth is the widest of zones, extending from 45° north to 50° south of the equator; while within it are others that foster maize, mandioca, yams, plantains, bread-trees, cocoas, sago, and others, so that man's larder is fully supplied with bread, and quite as generously with fruits, fish, and meats.

Sicily, Barbary, and Egypt were formerly the granaries of Europe, but are not now, because of the decay, not of the land, but of the people. The supplies now come from the south and south-east plains of the Baltic. Among the places of export is Dantzic, and it has sent out a million of tons of wheat and rye in a year. The average of Russian exports of the same cereals, from 1838 to 1840, was 4,500,000 tons a year.

When man enters this dépot for supplies, something more is required of him than when he applies at the storehouse of minerals. The latter are produced without his assistance; the long periods required for them to mature in, put it out of his power to affect them. He can neither change their quantities nor their qualities, while in vegetables he can do both. Had the nature of minerals been such as to admit of his labor in their preparation, it had certainly been required of him, since the purport of his existence was to be attained through his acquaintance with the compositions and evolutions of matter; but the processes of their formation are so slow, that had the tenure of his life extended into centuries, he could not have biassed their development. Now the producing powers of vegetation are so active as to induce greater changes in a day than do those that form minerals in a thousand years, so that he has every opportunity to impress himself on them.

But is it his duty, and has he the power? Undoubtedly; although it may be there are those who think he cannot meddle with nature's works without marring them. A great mistake. In this department she produces nothing absolutely perfect without him, and she will not. Designed for a nursery, it requires nurserymen. Forests and prairies are at large, what neglected farms are in little. They cover the ground with things growing rank and wild, and choking each other; they are what he himself is before being drawn out of the jungles of ignorance and improved by cultivation. The principles at work and the soil they work on are at his service; but like tools in a machinist's shop, their profitable employment rests with himself. They will cover his fields with wheat and fill his gardens with fruit, if he so wills, by properly exciting them. If he fold his arms in indolence, they will expend themselves in weeds. In this department man was to acquire a very large portion of his knowledge of matter, and of his experience as a manipulator; hence, whatever he has the ability to do, is left for him to do. Perfectly developed organisms are not produced for him, but their germs are supplied, and agencies to unfold and ripen them. Spontaneous growth shows the workings of these agencies, but not their perfect working; that is left for him to bring out.

In some respects, planters and farmers, florists and fruiterers surpass other elaborators, inasmuch as they join nature and improve her products before leaving her hands. They cause qualities to appear where they were not, and in greater or less quantities where they were. They diversify dimensions, colors, and texture. The variations and multiplications of plants, extinction of old and introduction of new ones, are with them.

It is, then, by bringing in plants from the wilderness, domesticating and carefully cultivating them, that they are to be improved. It is thus that the sloe-bush has been changed into the plum tree, and grasses into corn-bearing cereals. Vegetables are literal mechanisms for elaborating matter; and to improve their products, they themselves must be improved or changed, just as artificial contrivances are, when required to turn out better goods. Indeed, there have been made as great and beneficial changes in natural as in artificial mechanisms, and the future will no doubt record equally new achievements in both. The former can be multiplied indefinitely, and with infinitely greater facility than additions are made to looms and spindles. New varieties, moreover, produced by hybridity, and corresponding with new inventions in the arts, will never cease. Then as regards economy of space, a matter of the first importance in reference to a future densely populated world, it has been shown (in the Kew Gardens of London) that on an area where not over two hundred plants would grow in a wild state, twenty thousand have been made to flourish.

There can therefore be no doubt that as great and beneficent discoveries are to come out of the ground as have been, or will be made upon it, and that as broad, and deep, and fresh-flowing streams of intellect are required in the management of organic matter as of that which is immobile and dead.

Some political economists have declaimed against foreign commerce that exchanges flour, corn, and other products for hardware, dry-goods, and fancy merchandise; the fertility of land, the essence of it, being bartered for things that return nothing to replenish it. The fruitfulness of an island or a continent, it is said, may thus be exhausted. Can this be? Is there no compensating principle at work in nature to prevent so serious an evil, and one that might derange the whole economy of the earth? Surely there is, and is it not in the atmosphere? All plants derive their food directly or indirectly from it; and do not trade-winds, aerial storms, ordinary gales, and ceaseless movements in it tend to maintain an equal distribution of the matter it holds in suspension—sufficient at least to counteract general and permanent if not local and temporary irregularities. Plants raised in glass vases from earth weighed and dried in an oven were found to take nothing or next to nothing from the earth. The rich palm-oil of Africa is from trees that luxuriate in hot dry white sand; so it is with many or most of the cacti. The olives of Sicily flourish on rocks. It is indeed an agricultural axiom that a numerous people can never be absolutely dependent on the soil of other countries for food. In Great Britain and Ireland, are unproductive lands sufficient to feed over eight millions of additional population; and of England alone, the most cultivated of the two islands, it has been stated by competent authorities that the produce might be doubled.

On the limited state of our knowledge of vegetable arithmetic, Humboldt observes, that if we had sufficient grounds for believing that one half of the phænogamous plants were known, and taking the known at 160,000 according to one estimate, or at 213,000 at another, we should have to add from 25,000 to 35,000 species of the grasses. And as these appear to form one twelfth of the Earth's plants, the united numbers would only amount to one eighth or one tenth of the species that now exist?

The assumption that we already know half the existing species of phænogamous plants is further opposed by the following considerations. Several thousand species of Monocotyledons and Dicotyledons, and among them tall trees, have been discovered in regions considerable portions of which had been previously examined by distinguished botanists. The portions of the great continents which have never even been trodden by botanical observers, considerably exceed in area those which have been traversed by such travellers, even in a superficial manner. The greatest variety of phænogamous vegetation, the greatest number of species on a given area, is found between the tropics, and in the sub-tropical zones. This last mentioned consideration renders it so much more important to remember how almost entirely unacquainted we are, on the New Continent north of the equator, with the floras of Oaxaca, Yucatan, Guatimala, Nicaragua, the Isthmus of Panama, Choco, Antioquia, and the Provincia de los Pastos; and south of the equator, with the floras of the vast forest region between the Ucayale, the Rio de la Madeira, and the Tocantin (three great tributaries of the Amazon), and with those of Paraguay and the Provincia de los Missiones. In Africa, except in respect to the coasts, we know nothing of the vegetation from 15° north to 20° south latitude; in Asia we are unacquainted with the floras of the south and south-east of Arabia, where the highlands rise to about 6,400 English feet above the level of the sea; of the countries between the Thianschan, the Kuenlien, and the Himalaya, all the west part of China, and the greater part of the countries beyond the Ganges. Still more unknown to the botanist are the interior of Borneo, New Guinea, and part of Australia.

As, therefore, by the progressive exploration of new countries, we gradually exhaust the remaining unknown species of any of the great families, the previously assigned lowest limit rises gradually higher and higher; and since the forms reciprocally limit each other, in conformity with still undiscovered laws of universal organization, we approach continually nearer to the solution of the great numerical problem of organic life.

But is the number of organic forms itself a constant number? Do new vegetable forms spring from the ground after long periods of time, while others become more and more rare, and at last disappear? Geology, by means of her historical monuments of ancient terrestrial life, answers to the latter portion of this question affirmatively. In the ancient world—to use the remark of an eminent naturalist, Link—we see characters, now apparently remote and widely separated from each other, associated and crowded together in wondrous forms, as if a greater developement and separation awaited a later age in the history of our Planet.*

CHAPTER VII.

THE THREE STOREHOUSES OF MATTER.

3. ANIMAL PRODUCTS.

In this third department matter appears in types and forms widely unlike mineral and vegetable bodies. In one of those it is inert; in the other it has motion, but is tethered to the ground; in this it is locomotive. In the first it crystallizes, in the second germinates, in the third it lives, being endued with sensitive organs, and impelled by instinctive impulses. The change of an impalpable air—of matter so attenuated that leagues of it offer no ob-

* Humboldt's Aspects of Nature.

stacle to vision passing through it—to a gross liquid or solid, is marvellous; but not more so than the metamorphosis of common earth into fruit trees and flowers, into insects, reptiles, fishes, birds, quadrupeds, and men.

There is no medium adapted to sustain life but what is pervaded with it. While the torrid and temperate zones teem with living forms, the polar ice resounds with the cries or songs of birds, and the hum of insects. The atmospheric ocean, from its bottom on which we move to the elevations in which the condor soars, is redolent of life. But utterly innumerable as visible living forms are, their numbers are insignificant compared to the legions that the microscope reveals. Nor is it known where life is most abundant—on land, or in the unfathomed depths of the oceans.

As with plants, so it is with animals: they are natural apparatus for supplying man with materials for his fabrics, such as he could not elsewhere obtain, as wool, hair, feathers, down, silk, leather, glue, horn, ivory, wax, oils, furs, coloring matters, bone, pearl, tortoise and other shells, sperm, whalebone, isinglass, &c., &c.,—their numbers filling important pages in the catalogue of his working stock.

Now, though man cannot originate living organisms, he can control them so far as essentially to modify the products they yield him: a circumstance wonderful in itself, although being common no one wonders at it, and yet nothing less than a verbal or written declaration from above could more emphatically proclaim him a manufacturer than the power given him over the development of most of the substances just enumerated, and over others in the vegetable world. By them he learns that the two active departments of Nature unite with the passive (mineral) one in preparing materials for him. It seems strange that he should be trusted with the awful power to contract and expand the area of existence, and, consequently, its enjoyments; but as tenant and manager of the factory, and alone responsible for the manner of conducting it, he was left to determine what living aids he should reject or employ. As in the vegetable department, so in this, he was to have the means within himself of increasing and diminishing the materials he wanted.

Elaborators who provide materials for clothing and food operate chiefly on the soil and its products. While some devote themselves to fibrous substances, to cereals, sugar, fruits, and roots, others convert grass, corn, and potatoes into beef, mutton, and pork, into wool, hair, horns, and hides—operations that are as truly arts and manufactures as the casting of types or building of ships. Indeed, those whose producing apparatus are plants and cattle are, in some respects, superior to other elaborators, since they deal with matter in its highest forms of development. They diversify products, and evolve them with equal certainty and uniformity as operatives on inert matter. They improve them too, as do engineers and manufacturers, who, to obtain better results, alter or exchange their machinery. Precisely on the same ground do planters and herdsmen introduce new seeds and breeds.

A few items of the statistics of animals and of animal products will lighten the subject by breaking the monotony of its disquisitions.

The milch cows of the U. States in 1850 numbered

6,385,094, working oxen and other black cattle 11,393,813, sheep 21,723,220, swine 30,354,213, laboring horses, mules, and jacks, 4,335,669. There were, exclusive of the above, animals slaughtered for food, whose value was nearly 112,000,000 dollars, and whose numbers could not therefore have been under 20,000,000. The numbers for 1853, according to the Patent Office Report, were—Five millions of horses and mules, twenty millions of horned cattle, thirty-two millions of sheep, and twenty-three millions of swine. Arrange these flocks and herds after the manner of Jacob, allow ten feet for the larger and eight for the smaller, to prevent their treading on each other—mount five millions of drovers, being one to every sixteen animals—and the line would extend several times round the globe. But what are they compared to the wild animals that range the forests and prairies of the U. States! The buffaloes alone would form an unbroken phalanx round the earth, and the wild horses another. Still, to the quadrupeds of the world they are little more than specimens in a menagerie.

Of animal products leather is an ordinary one. Of the amount made in the U. States in 1850 we have no account, but the value of that worked into the single article of shoes in a single state (Massachusetts) is set down at twelve millions of dollars. The leather manufactures of England stand third or fourth on the list, being inferior only in point of value and extent to those of cotton, wool, and iron. She imported in 1851, and tanned 2,330,901 hides. She uses up yearly 60,000,000 lbs. of leather, and the value of the manufactured article is 70,000,000 dollars.

In 1800, England had 26,147,743 sheep and lambs. In 1854, the number in the three kingdoms was 32,000,000. She now imports (chiefly from Australia) 70,000,000 lbs. of wool, and clips from her own sheep 120,000,000 lbs., making one hundred and ninety millions of pounds of the fibre spun and woven by one people in each year. The clip of wool in the U. States in 1850 was 52,516,959 lbs. France ten years ago (1843) worked up 45,000,000 lbs. of wool annually.

Such are at best but a few solitary specimens of products furnished by domestic land animals. More might have been added, as hair, horn, and tallow—of the last, Russia, after supplying herself, sent 137,160,000 lbs. to other peoples.

Animals are not confined to land, water is an immense theatre of vitality. Why were two thirds or three fourths of the earth permanently flooded with this liquid? Was so large an evaporating surface required to supply rain to fertilize the soil and aid in breaking down mountains? Was so wide a receptacle necessary to receive the debris washed into it through one geological period, in order to digest and prepare undisturbed the sediments for reappearance in stratified layers in another? Had it special reference to aqueous life, or was it determined by these and by other requirements? Whatever it was that led to the present proportions betwixt land and water, they are doubtless beneficial in the highest degree, and perfectly fulfil every organic and inorganic condition.

Water is a distinct arena for man's enterprise, and as such it has incalculably extended the range of his thoughts and of his acquisitions. It teems with substances precious to him, and he can travel over it easier than on land. It presents no impenetrable thickets nor inaccessible mountains; and although as yet the basins of oceans and seas are imperfectly known, the same remark applies, though in a less degree, to many of the great slopes of continental valleys. In full one half of the earth there remains as much to be explored as in some of the seas. Subaqueous researches are not to be expected of man in the morning of his career; still he has turned and is turning his attention to them. Explorations of wrecks and other matters at the bottom of the sea are becoming common as descents into mines.

Between the ocean and the land are other analogies; the face of the former varies in color from the white surf and pale green along shores, to olive green and deep blue further out. Sometimes it is colorless and transparent, at others dull and opake. The Greenland sea changes from ultramarine blue to green and grey; at one time pellucid, and muddy at another. The Mediterranean puts on a purple hue, the Gulf of Guinea appears white, and the waters about the Maldives look black. As in landscapes, the colors are often due to the soil and to surface vegetation. Then the surface, as on shore, is broken by undulations, and at night lit up by phosphorescent animalcula—analogues of fire-flies. Like continents, seas and oceans are fertile fields of labor, and in some respects the most profitable, since their crops are raised without man's care, and he has only to reap them, as in whale, seal, cod, mackerel, herring, shad, oyster, salmon, coral, pearl, and other fisheries. The fecundity of the ocean equals, perhaps surpasses, that of the land. Its contributions to the arts are numerous and unique, while the streams of food it turns into man's garners never cease to flow. The fishermen of one nation have taken in one season, from the banks of Newfoundland, a million and a half of quintals of one kind of fish: in 1853 United States whalers brought in 363,191 barrels of whale and sperm oil, besides five and a half millions of pounds of whalebone. In 1850 the English home fisheries yielded 340,256 barrels of herrings. In 1852 the Scotch fishermen took 112,000 cwts. of cod and ling (mostly dried). The Dutch fisheries probably were more productive. The Scotch fishermen sent 3,192,672 lbs. of salmon to London in 1841. Yet all these put together form but a small item in the annual yield of the deep sea, shore, lake, and river fisheries of the United States, and an insignificant one in that of the earth's fishery as a whole.

Birds:—The three general forms of matter are the media of life on our planet, and on and in them respectively flourish the three great cohorts of living beings—of creatures that walk, swim, and fly. Air and water, essential to the concrete portion of the earth, presented opportunities for diversifying the forms and functions of life, and of immensely swelling the amount of sensuous enjoyment; hence, without affecting the applications of air and water to other purposes, they are made to sustain the countless hosts that live in them. In thus doubling, or perhaps quadrupling the numbers of sensitive creatures, the beneficence of the Creator is as conspicuous as his wisdom and power.

We reluctantly passed over the grasses, shrubs, and trees, without alluding to them as the abodes of what many consider the most strongly marked and attractive class of the lower tribes: and certainly, birds are singularly captivating in their forms, colors, and movements, the sweetest of songsters and the cheerers of man in his labors. Their subdivisions are such that they draw pleasure from every part of vegetation, and by feeding on its enemies they are its great conservators. But for them the earth had been barren as granite or a desert of sand; nor had there been a man living to till it. Scratchers seek their food about the roots, climbers hunt insects in the boles and stems, perchers feed and warble on the foliage, waders stalk among aquatic plants, while swimmers forage in deeper water. The swallow tribes course insects through the atmosphere; the accipitrines soar over all, prey upon all, and act as scavengers for all.

Birds do not elaborate as much matter for manufacturers as quadrupeds, but as protectors of vegetation the value of their labors is incalculable. Besides the flesh and eggs of those used as food, feathers are their chief offering. With those of water-fowl, pillows and beds are stuffed; and from the soft delicacy and non-conducting properties of down, it also is employed for the same purpose, but chiefly for various articles of female attire and accompaniments—tippets, boas, muffs, &c. Plumes of the ostrich and of other birds have always been worn as ornaments and insignia. Fans and screens are made of feathers, and entire dresses of them are common among Indians. From the variety and richness of colors in which birds are draped, artificial flowers have, for ages, been made of feathers.

Quills have been split and made into cheap and durable brushes, and also into hats and other parts of dress. But the pen is the most memorable application of the quill. In it birds have contributed more than all other classes to what has been deemed the highest of arts, the recording of thought. By the instruments of their flight man has soared into higher regions than the material atmosphere. In a mechanical and engineering view, the structure and material of feathers and of pinion quills are of surpassing interest. Of a singular composition of matter and moulded into peculiar forms, they, the latter particularly, combine unequalled strength and elasticity with the least weight of material; the qualities required in propelling organs. Every feather is a study in itself, and in the mechanism and movements of wings lessons of the highest practical value are to be learned.

The most singular, unexpected, and the largest contribution of birds to the arts is guano: a substance so rich in fertilizing power as to have become a staple item in commerce, and to afford employment for ships of all nations. In it the economy that pervades this heritage of ours is very obvious. Volcanic and other rocks appear here and there in the midst of oceans. Without vegetation no land animals can live on them, but they are the very places for oceanic birds to sleep and breed on, and for amphibia that seek dry land on which to expire. Hence guano has been accumulating on islet rocks for unknown periods of time, and is now dug out of beds varying from 50 to 100 feet in depth. It is found in African and Australian islands as well as in the Pacific. Samples from the Cape of Good Hope and Van Dieman's Land were at the London Exhibition. Thus have oceanic birds, in remote ages, whom men never saw, been laying up material for us.

The varieties of birds now on the planet are unknown; one naturalist has recorded 3,800 species.

Insects are interesting as birds. The most unattractive, if fully known, would appear beautiful as golden pheasants. A bee, a minnow, a beetle, and a common house-fly, are as great miracles of chemical and mechanical actions and motions as the universe itself is. Without irreverence, we may believe that in no world can there be more wonderful illustrations of what mechanism can do. Statuaries go into raptures over the Elgin marbles, and old men and youths gaze and copy their moving outlines of horses and men, while inventors turn not so much as an eye aside to study infinitely higher lessons that concern and are daily pressed on them. The time will come when their successors will be sensible of the advantages of contemplating the chefs-d'œuvre of God. Had the earth produced but single specimens of reptiles, insects, fishes, and birds, philosophers would have gone to the antipodes to witness their movements when living, and to dissect them when dead. One might almost be tempted to think it an error in the owner of the earth in giving us such numbers of his devices, since the more he sends the less they are regarded. But the days of sciolism are passing, and men will seek for higher lessons in manufacturing mechanisms than they learn from inorganic matter.

Animals are elaborating machines, and by carefully studying their construction and their actions, we may ascertain how each does its work, and imitate it. Their organs of elaboration, their processes, and the materials they use are as purely mechanical, chemical, and common, as those employed in artificial works; and so it is, that every class, order, genus, and species invites us into fields of knowledge that will never become barren of mechanical and chemical novelties; no, not if harvests be reaped every hour.

As yet man has pressed but few insects into his service, because his limited wants and researches have not made him acquainted with the nature and uses of ten thousand substances which these minute and most dexterous and delicate of elaborators produce. It is not, however, improbable that in time they will induce as great changes in the artificial as they have induced in the natural world. No works on earth approach in magnitude and durability some of theirs; and none tend more fully to illustrate our globe as one vast factory.

Silk-worms man has long employed. They are among the most industrious and profitable of his assistants. The fine, soft, and hitherto unparalleled thread they yield him is extraordinary; it were futile to attempt its measurement by yards, or even leagues. In the United States, in 1850, the census gives only 10,843 lbs, while in 1844 the amount was 396,790 lbs.* We know not what quantities are raised in Canada, Mexico, South America, and the rest of this western hemisphere. In Great Britain, about 5,000,000 lbs. are annually worked up; in France, much more;† then large quantities are raised

* Kennedy's Abstract of the Seventh Census.

† Besides the quantity manufactured and consumed in France, the enormous amount of 1,074,144 kilogrammes of raw and thrown

and woven in Austria, Prussia, Spain, Portugal, Greece, Switzerland, Italy, Holland, Russia, Turkey, Persia, &c. Yet the aggregate product of Europe and America must be very small compared to that spun by the worms of India, China, and the rest of Asia, by those of Africa and Oceanica.

Every thing about these creatures is surprising. How singular the contrast presented by their delicate natures and ephemeral duration with the strength and durability of their products! No sooner are they grown caterpillars, than they begin their filamental bobbins, and they live but a few days after finishing them—hastening to be dissolved in air to make room for fresh legions. But the thread they leave is lasting. Ladies' silk-dresses, after being worn through life, often descend as heir-looms through several generations. Then what is more remarkable than their numbers! There may be throughout the world fifty millions of persons engaged more or less directly in the manufacture of fibrous materials. Suppose one tenth of our living species, or a hundred millions, thus engaged. That number is truly a great one, but square it—multiply it by itself—and the quotient would not equal the hosts which the Proprietor of this factory has sent to make even one kind of thread for us. And moreover, swarming as they do, it rests with us to multiply them, and that indefinitely. To other tribes of insect spinners little attention has yet been given.

As elaborators of rich chemical compounds, bees have from early times been kept at work by man. The

silk was exported from the country some years ago. The amount is now probably much greater.

amounts of wax and honey they yield is prodigious. Those given in the U. States seventh census are alone at hand, and certainly do not represent a tithe of what might be procured. Nearly fifteen millions of pounds of wax and honey are given as the product for the year 1850. It would be interesting in these and all other articles, whether of food or clothing, to know how much is produced and how much might be produced, that by dividing the amounts by the number of our species we might ascertain how much each individual receives or might receive.

Dyes are mostly from other departments, but not altogether so. The famous Tyrian purple of old was obtained from a sea shell. The modern color is derived from an insect. Besides the cochineal the grana kermes furnishes another red dye. The lac dye is produced on trees by an order of insects. The amount of coloring matter these minute creatures furnish is also remarkable. Nearly two millions and a half of pounds' weight of cochineal were imported into England in 1850, and over two millions of lac dye. Thus some of our richest colors are from insects, and in the vegetable world from lichens, masses of weeds—from things insignificant and worthless in appearance.

It has been well remarked that numbers of new coloring materials have been in late times discovered and made available; so that the dyer of the present times employs substances of the existence of which his practical predecessors were wholly ignorant: and just such remarks will be made hereafter with regard not to our dyers only, but to almost every other profession.

Is it asked of what use are invisible animated molecules ever likely to be to man? What effect can they produce on matter serviceable to him? Why, there are examples of the accumulation of matter by them that are perfectly startling—that put at utter defiance the efforts of large animals and of man himself. Ehrenberg has shown that not only on several microscopic infusoria do others live as parasites, but such is the prodigious power of development or capability of division of the gallionellæ that in four days an animalcule, invisible to the naked eye, can form two cubic feet of the Bilin polishing slate, or tripoli!

It may have occurred to the reader that if animals were designed to supply materials for man, their numbers and developments should be found to excel within the human era, and to inquire whether they did not flourish in previous ages more than now. The interrogatory is pertinent.

Naturalists recognise a general law presiding over the animal kingdom. "Each group, each natural order or family, the history of which has been investigated, has manifestly shown a development parallel to that of individual life: 1st, an early period corresponding to that of youth, during which the group has but a small number of representatives: 2d, a period of full development, corresponding to that of the adult, during which the group exhibits the greatest diversity which was in its power to assume: 3d, finally there is a period of decline, corresponding to old age and fall, during which the individuals are less numerous. In the class of Mammalia there are comparatively few groups which have thus reached the third part of their history and passed away from the earth. The majority *attained their period of fullest de-*

velopment at the beginning of the human era, and are actually in existence upon the external surrounding crust of our planet."* But two groups are known to be on the decline, the Pachydermata and Edentata. At the same time, the most useful members of the former are more numerous now than at any former period. Thus it is found that animals most useful to man passed their nonage just previous to his appearance. The noble horse has come to us in his prime, the ox also and the sheep, the deer family and the camel.

So far as known, the same may be said of the most useful birds, and of the bee and silk moth among insects.

Some ask, what elaborators can learn from the organic world? Almost everything. We know nothing, or next to nothing, of the principles by which matter is elaborated in wool, hair, feathers, scales, horn, ivory, &c., &c., nor how colors are evolved, defined, limited, and mingled in the bodies of animals, birds, and flowers: how the metallic lustre in the peacock and other creatures is produced, how perfumes are drawn out of common earth—in a word, how every object in nature is produced as it is. This knowledge is to be acquired. Man is not for ever to be empiric.

* Classification of Mammals, by Professor C. Girard, Smithsonian Institution.

CHAPTER VIII.

MOTIVE POWERS.

Now provided with materials and with knowledge to use them, one thing more was wanted to render the factory and its facilities complete. Had man been left to the employment of his own muscular power, he could have made little progress as a manufacturer. His stock would have been vastly too large for him to work up, and his energies had been consumed, as in semi-barbarism, in gross labor; hence the crowning gift was a series of motive agents, by which his power over inert matter was increased immeasurably beyond what his own strength could have effected, and achievements made possible that otherwise could not have been imagined, let alone attempted. In making this assignment, the Proprietor of the factory completed his share of the contract—thenceforth the lessee was to perform his.

It need not here be stated with what facility man seizes and employs organic and inorganic forces—how the weak and the strong, the willing and wayward, the fitful and violent obey him—a facility he never could have acquired had he not been ordained to control them. Prime movers are the prime civilizers. Without them the natural world had been dead, and the artificial one stagnant. Of unlimited and lasting applications, their sources, like those of materials they are employed on, can never be dried up: a perpetual necessity, they are everlasting. At all events while the earth endures, the waves and tides of the ocean, falling and running waters, atmospheric pressure and currents, animals, steam, electricity, and other agents will continue. So will minor and local sources of power, as boiling springs, spouting fonts, burning wells, and all surface movements arising from subterranean heat and action.

Some coal-pits have long been on fire in Europe. The combustion, for want of air, goes on slowly. In Saxony the heat has been turned to account by market gardeners, who, in favorable spots, locate hot-beds, and raise southern and tropical plants. Thus, observes Kobell, it is the strange destiny of carbonized remains of palms, which flourished in long lost tropical climates, to force pine-apples at the present day.

The greater part of animal power at present employed is drawn from the equus and bos genera. Among them are the most valuable of laborers. They serve man over the largest part of the habitable globe, but there are wide districts to which they are not adapted, and there others are provided. The camel family is specially organized to labor in deserts: it is the sole medium of communication between those countries which are separated by seas of hot sand, and on which rain seldom or never falls. In the beautiful and expressive metaphor of eastern speech, the camel is "the ship of the desert," and, in truth, it is the only ship by which the wilderness can be navigated with certainty and safety. In hot regions the elephant toils for man, and in arctic circles reindeer and dogs. The ancient Peruvians employed dogs as well as the llama.

The actual animal power of the U. States in 1850 was represented by 1,700,000 working oxen, 4,336,719 horses, and 559,331 mules and jacks—upwards of six millions and a-half of animals of draught and burden.

The amount of water and wind power employed in the U. States is not known. The former is greater than in any other country.

Mechanical power is above all price, and yet the amount given out by inanimate matter that might be used is utterly incalculable. That which is ever running to waste in waterfalls and rapids is inconceivably great. It is within the range of possibilities that the ocean's resistless waves may eventually be used to aid in the propulsion of vessels, and do other work, by compressing air into chambers opened to receive their impulse—that is, to employ them as rising and falling pistons, in inverted cylinders, for urging it into proper reservoirs.

Then, again, in fields and forests, what power is lost, though presented in forms more tangible and accessible than in waves. A plan is wanted for collecting it from swaying boles and branches: one possessing the properties of an alleged discovery of an old inventor, by which in whatever directions the primum-mobile moved, up and down, sideways and every way, the desired result followed: a device which, working day and night, might accumulate power for planters and others, while they slept.

Trees while in motion give out more power in a windy day than would cut them down when at rest; and in all cases power proportioned to their magnitudes. Doubtless the idea of using such power will appear to many puerile and visionary; but for all that it is practicable, and some day if not in ours, will, we think, be turned to account. Farmers will not then neglect long swinging-levers radiating from boles around their homesteads, but make them serve as pump-handles for raising water for their families and cattle, and for other purposes. Movable windmills have, at great expense, been put up to do what a single stout stem, or two or more united, could perform.

The mechanical and engineering world has been much excited of late on the subject of an efficient new motor; a desideratum calculated to inaugurate and give tone to a higher civilization. There is a prevailing vagueness in the minds of many inventors on the employment of heat as a motive agent, that has led to great and useless outlays of thought, money, and time. They forget that each pound of coal can only give out its equivalent of power, and that water, air, alcohol, chloroform, bicarbonate of sulphur, or any other fluid with which boilers are charged, are mere vehicles or media for employing the heat. The heat is the power, and all that can be accomplished is economically to evolve and apply it. One medium may be better than another, still power comes out of the fuel.

There may be other fluids, natural or artificial, that possibly may prove preferable to steam in particular circumstances, and to a limited extent. We know not what science is to disclose, and it would be unwise to assert that a better one is not to be had. Still, with our faith in nature as a guide, and that on so momentous a question she has made no more a secret of a general agent of power than of the materials power is wanted to work up, our hopes are not strong. Steam is the grand medium she uses. By it she produces the great moving powers upon the earth, and most of those within it. And as if it was to be the cheap and common agent in the arts, she has given us the substance from which it is evolved, and the means of evolving it in the largest profusion—water and fuel. The first costs nothing, the other but little, and that little will be less as the vast stores become opened. Engineers have yet to learn how direct a teacher nature is.

Another idea has been and still is maintained, that heat can be used as a motive agent over and over again: in other words, that power can repeat itself. Could this be established, its demonstration would be cheaply purchased by an outlay of millions of dollars in experiments.

Mechanical powers being the result of matter in motion, are comprised in two general divisions: 1. Such as come from matter put in motion by nature, and, 2. From matter excited by man. Of the latter, comparatively few have yet been developed. Various in their forms and modes of action, they are based, as all must be, mediately or immediately on heat. The glowing sun is the Great Prime mover in the natural world; and, that we might give motion to mechanisms where natural motors are inapplicable, we have been furnished, in inflammable materials, with the means of kindling artificial suns. Some motive agents may appear to have little connexion with heat, as gunpowder, carbonic acid gas, and electro-magnets, but the power of all is referable to it. Investigation would show that their energies are derived from the heat, natural and artificial, expended on their ingredients and application. In fuel, then, is laid up man's chief store of artificially excited power, and here we again perceive the intentions of the Creator in what have been named "carboniferous periods," when vegetation was so rife and active in elaborating coal for us. If the earth shows foot-prints of the deity, coal strata bear the impress of his hands. He has legibly written on them, "To artisan man." (See Chapter 4, Section II., for Mechanical Forces.)

Before closing this division of the subject, the adaptation of the earth's surface to facilitate a general exchange of the results of labor should not be overlooked. It is a system of intercommunications. There are few inaccessible districts; its high and low lands, its seas and rivers, are open passages for intercourse with every part. They are natural roads and canals, which have suggested the diversities of land and water carriages, and means of propelling them. But mountains obstruct the traveller's path? Not more so than piles of lumber, coal and ores in builders' and founders' yards, interrupt the walk of their proprietors. Natural elevations are stores of unwrought goods, and is it not better to turn aside and pass round or between them, than to be without them? They may appear to us utterly exhaustless, and some perhaps of no use, but we live in early times; a thousand centuries are nothing in the life of the world: they will all be cut down and used up by our successors, and others will be raised for workmen that will succeed them.

As to oceanic obstacles to free communion, they are imaginary, and belong to early phases of civilization. Navigation has been attained, and we can imagine how limited without it trade would be; how many arts would be unknown, and even incomprehensible, if there had been no locomotion but on solid ground; and how bald and poverty-stricken our fund of ideas, if deprived of those that arise from the terraqueous character of our orb.

There are, however, two portions of the earth's surface from which man is excluded—the polar circles. They are evidently not intended as arenas for human exertions. Their functions have reference chiefly to general temperature and ventilation. They promote a healthy circulation by drawing towards them the heated vapors of the torrid regions; they induce aqueous as well as atmospheric currents; and they afford secure retreats for swarms of fish, and other creatures. It is well for these that man is shut out, since he has hunted some of them in the open oceans till they have become few, and were his present eager pursuit of them within the arctic and antarctic zones not arrested, they would inevitably be exterminated. At all events, the enduring barriers of ice are not simple incidents of climate, but organic features in the economy of the planet.

In conclusion: To meet man's wants through the entire cycle of his destinies, to furnish employment for the varied world of thought within him, to keep pace with his enlarging grasp and power, it was necessary that suitable materials, and objects, and forces, and theatres of action should be provided for him. And so it is, that there is no substance, quality, or condition of matter but what tends to further his operations as a manufacturer; none which does not exhibit the world as a factory, and him in charge of it; and which does not show that such was the grand scope and design of the Creator in preparing it, and placing him on it. The wonderful processes through which this factory has passed, to make it what it is, and the time required for them, indicate its duration. It has cost too much for a temporary workshop or shed—the Divine mechanician uses none such—too much to be destroyed before its elaborated treasures are worked up, or its resources half understood. No engineer erects a costly structure, furnishes it with expensive machinery, and ere it be put in successful operation, tears it ruthlessly down; much less can it be supposed that the Builder of this splendid one will act in like manner. For countless ages it has been in the sole possession of the lower tribes, whose presence and labors were necessary to prepare it for man. Surely the periods it is to be under the control of him for whom it was chiefly made, cannot be less. The period of occupancy will be proportioned to that of preparation, and as one has been, so will the other be—diuturnal.

To meet objections that may possibly be taken to the foregoing views of the earth, as partial and contracted, it may be well to state here, that it is not pretended that materials in mountains, for example, were raised solely for manufacturing facilities. Every person knows that these elevations diversify climate, temperature, vegetable and animal products, and life. The ocean, as the highway of nations, interferes not with it as the home of special orders of animals, and the same may be said of the land. So also with regard to the central fire engine; besides elevating materials for man, it performs innumerable other functions, in accordance with a cardinal law of the planet (and of the universe), that nothing exists or subsists for itself, or for one purpose. Everything, from a mountain to a fly, is influenced by the whole, and reacts on the whole. But this does not in anywise conflict with the predominating characteristic we have ascribed to the earth. Is there any other designation so comprehensive and literally appropriate and true?

SECTION II.

OF MAN; HIS NATURE, INSTINCTS, AND ACHIEVEMENTS.

CHAPTER I.

MAN'S FORM AND STRUCTURE INDICATE THE ARTIFICER.

Now let us turn to man himself, and see if his form and structure, instincts and achievements, do not indicate the nature and purposes of his being. Observe the perfect freedom of his upper limbs to operate on matter, in consequence of their being released from the labor of sustaining the body and aiding in its locomotion; a feature peculiar to his species, and the one which specifically proclaims him an artisan. Mark the termination of those limbs in the hands; the adaptation of these to work in all substances, their duality, the double-jointed levers they are attached to, their lithe and diverse movements, their power to grasp objects of every shape, their durability under incessant wear and tear; the articulations of the wrist and fingers to avoid the necessity of always moving the arm with them, and of a consequent waste of power; the sense of touch in the fingers, so exquisite and so active in a thousand acts. In the large development of the thumb man's superiority as a manipulator largely consists; it has been named a second hand. Still, it was in the unoccupied levers at whose extremities the fingers are, that his instincts as an artisan resided, and through which they have been manifested. Had those levers been employed as in their nearest analogues, man had been at best but an improved orang-otang, but in disengaging them from other service, and placing them as it were like laborers in the market-place waiting to be employed, the Creator gave us in them the prime instruments of our elevation.

Wonderful as are the capabilities of the manipulating organs of many of the lower tribes, they do not equal in number and diversity those of the human hand. In this instrument man's superiority is as marked as in any other, while it indicates with unerring precision what the chief employment of his earthly existence was to be.

If we revert to his entrance into the world, we shall be led to the conviction that he is created an artisan, and sent here to exercise his vocation. What were the things on which he opened his eyes, and which continued through life to arrest his attention, but those of a factory crowded with work! "All things," saith the Preacher, "are full of labor," and so full that man cannot utter it. The more he observed the earth, the more he found it the theatre of ceaseless manufacturing activities:—Its forces, chemical, electrical, and mechanical, latent and palpable, imperceptible and overpowering, never sleep. Without intermission, they are converting elemental matter into animal, vegetable, and mineral, into solid, liquid, and gaseous bodies—ever breaking up and renewing them. Every foot of it is paved with influences that are decomposing ingredients of worn-out fabrics, preparatory to their being again made up into similar things, or in gathering them up for other commodities. There is no suspension of the work on account of the moving-machinery, no waste of power, and no refuse material—not a scrap but what is worked up. The supply keeps pace with the demand, and, as with human merchandise, the goods vary with what they are made of, and their style with changes of times and seasons :—a perfectly organized manufacturing establishment.

Born and brought up in the busy scene, confined for life to it, having no ideas but what are derived from it—a true factory child—what else could he do but in the theatre of action assigned him imitate

"The Great Artificer of all that moves!"

His instincts, organization, and condition defined his profession, and compelled him to assume it. In no other capacity could he work his mission out. He saw that the Proprietor had furnished him with raw materials, not with finished goods. He had corn, but no bread; fuel, not furnaces; clay, but neither bricks nor tiles; sand, but not glass; textile substances were supplied, but he was to convert them into plain and ornamental fabrics: iron was given, but not in bars. The properties of alloys he was to find out, and discover the means of producing a prime material for cutting implements and tools. He essayed these things, and succeeding, his natural career opened before him.

As no factory involving a multiplicity of operations can be carried on without diversity of talents in the workmen, so this diversity is a prominent feature of the plan on which this earthly workshop has been established. If the work given to man was to be uniform in its character and applications, if it was to be limited in its kind and stationary in its results, no difference in the qualifications of operatives would have been requisite. When once the tasks were learned, nothing would be wanting but instinctive repetitions of them. The establishment would resemble one of those mills in which certain kinds of goods only are fabricated, and where certain sets of ideas suffice for the fabricators: all would think and act alike, and tameness and sameness pervade the whole. But if the productions were to be varied like those of nature, then equal, that is endless, diversity in the capacities and tastes of the elaborators was essential, and hence it is that no two individuals are in these and other respects the same; thus variety is the law of human arts, because it is the law of human perceptions.

Besides this, the Creator has divided the species into races or varieties, distinguished them by organization and color, and marked diversities of intellect in them by these also. Is it asked, why these subdivisions and distinctions? In the first place, they characterize every genus and species of physical beings. Climate and climatic productions seem to call for them; certain animals, as well as plants, flourish only in certain localities and latitudes, and so it is with human tribes. It may therefore be inferred that differences in the physique of men were, among other reasons, ordained to meet differences of climate, and though mind of itself may have nothing in common with matter, its discipline and developments are materially affected by the things upon which and the circumstances under which, it is exercised. While its nature is everywhere the same, it may be germinating as a seed among weeds in one zone, in another as a shrub throwing out fresh leaves, and in another rising into a vigorous tree.

The climates of colored men are all rich in materials for the arts, while on them they have expended little thought—much less, it is said, than might have been expected. This is simply because progress made by other races has not reached them. No race can progress of itself, and no one is independent of another; a chain of obligations and advantages unites all. The one that is lower in the scale than another is waiting for assistance from without. We are too apt to contemplate the man of Africa in an isolated position, and expect him to originate and prosecute improvements independently of others; whereas, taking all things into view, he is no more obnoxious to reproof for non-progress than the whites. It is but yesterday, comparatively, that most of them emerged from rank barbarism.

Another reason for the creation of races we may presume had reference to the furtherance of the work by dividing it, and assigning such parts to each as each was best adapted to perform. This is so beneficial, so obvious and natural a process, that it is evolved more or less in all communities. In factories men are selected for their fitness for particular performances, that skill and intellect may not be consumed where not wanted, and that the work might not suffer by incapacity taking the place of talent. Were there no variations of mental capacity and disposition the world would be in a perpetual uproar. Like ambitious players, few would be satisfied with the parts assigned them. If all were engineers, who would attend to the furnaces? But the Creator has settled all by graduating intellect and temperament so as perfectly to meet all contingencies.

But why should not mental capacity be uniform in the species, if even its development be unequal in races? The answer is in the fact, there is gradation in all things. Intelligence diminishes from God to man; and from man it flows, or seems to flow, in constantly narrowing channels, down to vanishing points in the lowest phases of animated matter. In passing through species, as through genera, it continues its resemblance to a conical tube which at no two points is of equal capacity. This inequality in human, as in lower families, shows that economy in the outlay of reasoning and perceptive faculties is as much a natural law as in the expenditure of external materials and forces. No greater capacity is given than can be employed. Where less is given the work requires less, and hence variation in human races implies, as in the animal world, variation in their work. Of necessity, superior intelligence, whether in nations or races, will always rule. Were the Creator surpassed in knowledge, he would cease to reign: nor is there any ground for dissatisfaction here, since inequality is a law pervading all orders of beings. If the tube be slightly larger on one side it is smaller on the other, and there is no end to it in either direction. There are as marked disparities in dark as in light-colored races, and there are black tribes equal if not superior in capacity to some other varieties. Color alone is not the criterion of intelligence.

Many persons, in their denunciations of slavery, erroneously insist on an original or innate equality of mental capacity in all varieties of men, and that all may be brought to the same actual level; but no such anomaly in creation can ever be. It would be fraught with evil. There would be an end to progress, and to all stimulus to progress. But this absence of uniformity in races neither prevents nor limits improvement. They will advance in their order. The lowest may accomplish the same things as the highest, but not in the same era or age. Pioneer races will take the lead, and communicate the impulse of new movements to those in the rear. The human sloe will become a plum, and the almond a peach; but if the colored people of the earth attain in the course of time all that white men have now acquired, there may then be as great a difference between them as there is now. Cultivation works wonders, but it cannot break down natural distinctions. In nations society is made up of classes: in society at large races form the classes; and as in enlightened countries people generally have acquired conveniences that were formerly deemed luxuries for rulers, so it will be with races.

It is a scriptural doctrine that knowledge is to cover the earth, and so it will; but neither knowledge nor its fruits can at any time be everywhere the same. Gradation will ever characterize the face of the planet. One district will be in advance of others as long as one race precedes others. As a whole it will be improved, but not equally in its parts :—a beautiful provision, since if the arts and sciences were equally cultivated, there would be no exchange of knowledge in them, and little to foster national intimacies and universal brotherhood. The great social bond between peoples and countries would be vitally weakened, if not broken. Whether the earth's colored artisans will ultimately and exclusively hold their native homes, and prosecute the great work of civilization by themselves, time only can tell. It seems natural that it should be so ; but communication with other races will always be indispensable. Universal progress can only arise from and be maintained by universal intercourse.

The plasticity of the human constitution is very great, but there is no probability that the white race can of itself carry and sustain progressive civilization over the tropical belt—hence the wisdom that has provided workmen for every zone. It is the belief of many that white men slowly but certainly degenerate, physically and mentally, as they approach the tropics. The fact, if it be one, is a proof that races can only permanently flourish in the zones to which they are indigenous.

We have so long been accustomed to contemplate mankind as one family, of one date and place of birth, uniform in innate capacity, and ordained to the same earthly destiny, that it seems to many wrong to speak of races, differing as much in the periods and places of their advent as in their organization. There is no difference of opinion about the fact of sections of the earth's surface maturing in different epochs, involving intervals of incalculable duration ; the question is, were these sections colonized from older ones, or were they independent centres of human and animal life? As respects the inferior tribes there seems little room for doubt, since sections of most recent formations have animals peculiar to them, and such as correspond with fossil analogues of other lands when in the same stage of geological development: nowhere else extant, they could not have been brought in from abroad. There appears also ground for applying a like remark to the human occupants. If they were emigrants they should indicate whence they came, and the people to whom they belonged; instead of which they exhibit characteristics of distinct races—of varieties neither allied to nor to be merged in others; such as the men of Africa, of America, and of Australia. The last named country is allowed to be of the latest formation, and the latest occupied; and there, man appears in the lowest forms of humanity, and is associated with the lowest types of animals and plants. According to the colonial theory, the latest colonized countries should bear definite evidence of at least some degree of a civilized origin.

CHAPTER II.

ORDER OF MAN'S APPEARANCE ON THE EARTH'S GREAT SECTIONS.

We know from the earth itself that man made his appearance in different countries at different times, though whence and how he reached them we have nothing conclusive. We can however trace, and with every indication of certainty, the geographical and chronological order of his entrance on the earth's great sections, in the indigenous vegetables and animals of each. We know that the country of the ornithorhynchus and kangaroo is passing through processes of development which Europe and Asia myriads of ages ago underwent, and that where the opossum still lingers the country is of more recent formation than the eastern continents; and therefore it is inferable that the red man is of a later origin than the white man, and the tribes of New Holland younger than those of the Americas.

Then, there is an observable and characteristic connexion between the races and their bread plants: the latter rise in the scale of development with the former. The Caucasian had the highest of the cereals—wheat; the Mongolian, rye and buckwheat; the Malayan, rice; the African, millet; the American, maize and mandioca; the Polynesian, yams; while the Australian had not attained to so much as the cultivation of roots, much less that of grains; and was, moreover, without a single one of the species of quadrupeds essential to civilization.

Facts not unfavorable to the hypothesis of several centres of population, may be found in the absence of uniformity in staple, primitive arts. Ideas common to the species are often wrought out differently by races, and so differently as to show that no connexion could have originally existed between the parties. As might be supposed, the conceptions are found further developed on the older than on the later continents. A few examples are added.

1. In spinning, the device of the Aztecs, Mexicans, Peruvians, and their descendants, varies so much from that of the eastern hemisphere, as to be irreconcilable with a knowledge of the latter, or of its users. The spindle, instead of being suspended by the thread, and whirling free in air, was and is spun round, like a top on its peg, in a fixed or movable cavity. Moreover, the distaff, an inseparable part of the oriental apparatus, was wholly unknown to occidental spinsters.*

2. The amount of pottery made by old Americans is almost inconceivable. It is found scattered over the greater part of New Mexico, and in some parts abounds on the surface continuously for from twenty to forty miles. Most of it, and much of that made in Central America and Peru, indicates correct taste in forms and styles of ornament. Now the whole was fashioned without the potter's wheel; an instrument dating behind the dawn of history, in the eastern hemisphere. The Egyptians represented "Amun, the Creator," forming worlds upon it, and turning it with his foot. The only aid to the fingers attained by the advanced nations of America consisted of moulds by which shallow vessels were modelled whole, and others in halves and smaller portions, which were united while the clay remained plastic. Nearly all vases into which the hand could not be introduced, were thus made. The lower portions of small vases were formed in moulds, and the necks gathered in by hand.

* See the Report of the United States Commissioner of Patents, for 1850, Part I., for an article on this subject; and a paper on Aboriginal Arts and Artisans, with illustrations from Mexican paintings, in the fourth volume of Schoolcraft's national work on the Indian Tribes.

3. Another example is furnished by the *quern*, or hand-mill, which was as common in the eastern half of the world, ages before Solomon or Homer, Moses or Job spoke of it, as in subsequent times. The red race never knew it. They had the pestle and mortar, its remote predecessor; and some had realized its immediate forerunner—a large, flat stone, and a smaller or movable one for the hands, to push to and fro. Between these corn was ground. By inclining the body, so as to throw its weight on the hands, the operation was tolerably efficient, but exceedingly laborious. Such was and still is the mill of the most advanced of American tribes.*

4. Besides the absence of the distaff, potter's wheel, and quern, another domestic implement should perhaps be named—the *lamp*. It seems almost impossible that the people of Mexico, Central America, and Peru, could have made the progress they did in the arts, and be without artificial lights in their dwellings, except what they had from slips of resinous woods. And yet I am not aware that any such thing as a lamp or a candle has been found in ancient graves, or dug out of the ruins of Aztec cities.

These are simple facts, but they furnish pretty strong evidence that civilization was as independently developed on this part of the earth as on any other part.

Again, if the Australian continent were peopled from an older one, indications of the arts of the latter should,

* See a representation of women of Zuni, New Mexico, grinding corn with their native mill, in Captain Sitgreave's Report of "An Expedition down the Zuni and Colorado rivers;" published by order of Congress. Washington, 1853.

as already suggested, appear and even abound. But, instead of this, the people have no traditions and no arts —neither spinning, pottery, nor even the mortar; and yet, as if to strengthen the hypothesis, they have realized a device in the boomerang which, it is believed, has no prototype in other lands. The throw-stick of the Egyptians and other ancient (and modern) people does not appear to have been in the least allied to this singular missile.

It has long been the fashion to consider the primary arts as descended from one source. They may have come from one to us, but so far from being exclusively due to any one people, they are the natural fruit of human organization in all lands. If a second cataclysm were to sweep mankind off to-morrow, except one family, they would be revived independently of any previous knowledge of them, just as would those of the bee and the beaver. Were it not for a feeling allied to pride, the construction of huts, evolving fire, ensnaring game, and cooking food, spinning, weaving, canoes, and other devices more or less common to barbarians, would be admitted to be suggestions of instinct, just as contrivances not inferior to them are conceded to emanate from the same principle in lower tribes. The difference is, that with man the arts are progressive, and with animals stationary —though not absolutely so, since some decidedly modify their staple devices under marked changes of circumstances.

Another singular notion is, that barbarism is not a simple but a highly artificial state: that the original condition of man was one of profound knowledge of nature, and that ancient and modern civilizations are débris of primeval science and refinement! This is reversing matters—making the stream dwindle as it flows, instead of gathering breadth and depth and momentum from swelling tributaries. It is like building an inverted pyramid, beginning at the base, and suspending the base from a point. The idea is not only opposed to all experience and observation; to the earth's records, which everywhere preserve specimens of the first arts in arrow and spear heads of flint and axes of stone, instead of philosophical remains; but is expressly contradicted by all histories, sacred and profane. They describe the first men and women as destitute of clothing, dwellings, fire, and consequently of artificial light, and of the metals. If they possessed high theoretical knowledge it was clearly useless to them. Had they known better, ought they not to have done better?

It is natural to ask, What part or parts of the factory were first matured? And where and when did our forefathers begin their labors on them? The answers are written upon it, without and within; and when, in the course of time, they become clearly translated, they will be found full of interest and instruction. If we take up an atlas, and turn to the usual hemispherical maps on polar and equatorial projections, we perceive how greatly the land preponderates in the northern half; while the southern one is a continuous ocean, broken only by the lower portions of Africa and America, with Australia and scattered islands, most of which appear to have emerged from the waters long after the continental tracts on the opposite side of the equator had risen. Now, history coincides with what reason suggests—that it was on the northern hemisphere, the earliest and largest arena provided for him, that man first made his appearance. But this vast area consists of two very unequal parts, separated by two oceans. The North American continent is one; the other, three or four times larger, includes the whole of Europe, Asia, and much the greater part of Africa. On which did men first open their eyes? Certainly on the one that was first prepared for them; and which of the two that was, history, tradition, and geology point to the largest.

But it may be asked—On what part of the northern hemisphere did man begin his career? There is no doubt—there can be none—that by the same law which assigned to all species of lower tribes their appropriate homes, man was put in possession of his first one, there being nothing arbitrary in its selection. Now, if there is a natural line or parallel more favorable than another it undoubtedly is the true one. The equator is by far the most marked of terrestrial circles, but there are strong reasons against it. If lands under it were most favorable to human development, they would have been continued round or nearly round the globe; instead of which, out of 360 degrees, water sweeps over 275. There is not a spot, or hardly a spot of land, cut by the equinoctial line in the Pacific ocean, from the Spice Islands, in 130° east longitude, to the coast of America, in 80° west; a distance of between ten and eleven thousand miles. Following it across South America to the mouth of the Amazon, it passes over 60 degrees in the Atlantic ocean—one-sixth of the earth's circumference—more of unbroken water to Gaboon, in the Gulf of Guinea; continuing thence to Zanguebar, it ranges over four thousand miles of the Indian ocean, till it touches the Malayan group whence it started—Sumatra, Borneo, Celebes, and the Spice Islands.

Thus a very small part of terra firma is under the line. Europe and Asia are entirely north, and so is the largest of the American continents, while the great expanse of Australia is away south of it. It crosses Africa, not at the widest part, which is from 60 to 70 degrees, but where the width is reduced to 35 degrees. So also, the broadest part of South America approaches to 50°, while under the line it is less than 30°. These facts are full of meaning. They show, if nothing else had shown, that an equatorial belt was not designed to be an early centre of civilization. If it had been, so much of it had not been buried under water. No science and no arts have emanated from it; and so far as the countries have been explored, the whole (a few minute spots, the fruit of modern efforts, excepted) abides in primitive wildness. We must therefore look elsewhere for the most congenial theatre of human development; for wherever that was, there the arts began.

Land being the proper theatre of man, should we not turn to the largest tract? If the fact of a comparatively small field appearing on the equator, and in disjointed and widely separated portions, predicated too limited and too interrupted an area, the converse may have been at the beginning true. As civilization was not to flow from the equator, it must have arisen at some distance from it, and the question is, at what distance? There are two other great natural and influential lines that intervene between the torrid heats and polar colds—viz. the tropics. Their influence on the vegetable and living world, and on human as on animal developments, is unquestionable. Passing round the earth at 23½ degrees from the equator, they are three times that distance from the poles; but as the circles or parallels of latitude diminish from them to a mere point at the poles, they are all powerful in the distribution of heat over the hemispheres, and in determining and locating the mean temperature.

They seem intended for the base lines of civilization. Let us see how this accords with known and acknowledged facts. Immediately above the northern tropic is the widest stretch of continuous land on the face of the globe; extending over 135 degrees of longitude, and running through what have always been deemed the earliest-peopled portions of the earth, and those, too, from which the arts are acknowledged to have descended to us—China, India, Persia, Arabia, Egypt, and the anciently advanced states on the northern shores of Africa, from Barca to Morocco. Then, if a perpendicular or meridional line be drawn through the middle of this land, it will pass through Arabia, Persia, and the Caspian, or vicinity of the Caspian lake; and the place of intersection will be found *the centre of the largest and earliest of the earth's land sections.* It need not be remarked how the location coincides with the oriental and scriptural accounts of the birth-place of man (or of the Caucasian race). Nor yet, that in the same region the best of the pulses, of esculent roots and fruits, the highest of the cereals, the three great staple materials for clothing, and the most valuable of domestic quadrupeds were indigenous. Here were fertile soils, genial climates, and everything else favorable to physical and mental vigor.

The arts at the earliest times inclined northwards, and so they have continued to the present times. Between the parallels of 10° and 40° all the famous nations of old flourished. None extended their influence to the equator. It was the same on the western hemisphere. Mexico, Yucatan, and the central American states are within the same parallels, or rather between 10° and 30°. Ancient American civilization never passed the isthmus, and consequently never reached the regions of the Amazon.

In the eastern hemisphere there have been no occupied and active centres of civilization south of the equator, except what modern colonies are producing, and hence it has never reached the line in that direction. In the western hemisphere the Inca dynasties, or their predecessors, extended their imperfect civilization along the Pacific coast *from the tropic* to 40° south, and also north quite up to the equator in a narrow and mountainous region, which from its elevation rather resembled a temperate than a tropical cline.

Without amplifying the foregoing facts or adding to their number, enough has been said to sanction the position assumed that the tropical lines are the natural bases of civilization throughout the earth. And here a parting glance at the map again reminds us that this mundane factory is only emerging from the chaos attending its erection; that but a small part of its machinery is yet put in play; and that, so far from ourselves and our immediate successors being among the last and most enlightened of its operatives, many epochs have to pass by before it becomes in full working order—so vast is the amount of ground to be covered, and work to be done.

CHAPTER III.

ELABORATORS AND THEIR WORK.

The various forms and qualities of matter, associated with the multiplicity of human habits and inclinations, predestined, as already intimated, the divisions and subdivisions of elaborators. Two important consequences followed :—The work could be prosecuted with system and success; and the workmen united by ties of mutual dependence and support.

There was to be no remission of labor; no stoppages of the work from lack of raw or a surplus accumulation of wrought material. No means were provided for laying up in one age a stock of goods for another. Each generation was to labor for itself; a law on which hangs the continuance of living bodies. If the present race of bees, for example, were to elaborate honey and wax sufficient to supply their young through life, and thereby render them independent of labor, the succeeding generation would perish, and the species become extinct. It would be much the same with us. All creatures are made to labor, and their enjoyments to depend on their industry.

As a wise proprietor, the Creator determined the seasons or hours of work by adapting our organization to the length of days and nights, or periods of activity and quiescence. Had we not been ordained to labor we probably had known no night, and consequently nothing of the sweets of rest after fatigue, or of the renewal of vigor and elasticity from repose.

I believe the average duration of human life is favorable to progress in the arts, and that it has been determined with reference to them. It is long enough to mature the faculties and afford them full employment in their maturity; so that society can be benefited by the ingenious and industrious of each generation, and not be embarrassed for a longer period by the indolent and dull. They who do no good in sixty or seventy years would do little in twice that time. If the lives of artificers rivalled those ascribed to men in the first ages, it is evident that expansion of mind would not keep pace with their years; while their energy and enthusiasm would certainly flag. And what a drawback on the world's industry, if the improvident and unproductive had to be fed, and clothed, and cared for, during eight or nine hundred years!

No factory can be successfully carried on by superannuated operatives; hence the Proprietor of this earthly one, in limiting the period of service in it, has provided for perpetual accessions of new and vigorous hands, and consequently of new and improved products. But for this quick succession of employees there could probably be no rapid increase of ideas, nor anything like the healthy excitement on the subject that is beginning to pervade men's minds. Now, more than ever, are many stimulated to surpass their predecessors and to leave impressions of their genius behind them. To the credit of such, an increasing balance will be recorded long after they have left the establishment, while the accounts of the unprofitable will be closed with their discharge, and their names expunged.

Men may eat, drink, and sleep for a century, and not live a year. Food and rest are simply means to aid us in accomplishing the objects of life. We do not make steam-engines for the sole purpose of decomposing fuel, nor has God made us only to consume victuals and wear out clothing. Like artificial motors, we are created for the work we can do—for the useful and productive ideas we can stamp upon matter. Engines running daily without doing any work resemble men who live without labor; both are spendthrifts dissipating means that would be productive if given to others.

Another feature in the administration of the establishment is, its employees are kept ignorant of the periods of their discharge. None know how long they are to be employed; and though liable to be dismissed at any moment, the knowledge of this does not make them one whit less energetic in their callings—a fact unaccountable on the ground of reason alone, but it was indispensable, and hence the principle on which it rests was implanted in our natures. Thus the work progresses, although workmen are hourly called away from it, and in the very midst of its excitements.

The succession of life is a most beneficent feature in creation. Surely, it is better that millions should enjoy life than a few scores. As for the pains of dying, they are momentary, while enjoyment is the attribute of existence. Moreover, pain in life or death is due to the violation of natural laws; but for this we should withdraw as easily from life as do the lower tribes—drop as ripe fruit into the ground. If it were not for the succession of life we should have neither animal nor vegetable products. There could be no arts.

The bent of man's nature, or his instinct, is as manifest in his works as are those of animals in theirs. The tenor of his life has been to invent and construct; and now that science is espoused to art, the entire face of the world is rapidly assuming a manufacturing and mercantile aspect. Its circumnavigation on commercial adventures is becoming an every-day affair. Agriculture, arts, and commerce, comprise and represent the material purposes of the earth's creation. Through them, as through channels, man's exertions instinctively flow, and by them the volume and velocity of his efforts are measured. Belonging to all lands, their elements are varied in all. One zone is rich in materials not known, or partially known, in others; hence arise systems of trade, by which products of nature and art, however local in their origins, become universally diffused, and mind and genius circulate with them.

Without this principle of giving one thing for another there could be no professional employments, and no exchange of thought. Without buyers there could be no manufactories. Without them this world had not been one. It has no foreign commerce, no correspondence with neighboring or distant orbs, because it produces nothing which their occupants want, nor do they raise anything essential to us. Had an exchange of merchandise been beneficial, it had been instituted. The earth's fabrics are therefore designed for home consumption, and domestic demands require them all. By diversifying the character and qualities of matter, and so distributing it that each people has something which others require, every man becomes a dealer with all other men; and thus the fraternal principle of international exchange is revealed, and its application rendered perpetual. A market is provided for the world's productions that can never be glutted.

Tilling the soil and subjugating animals is only half complying with the prime stipulation in the great charter. It implies—Have dominion over inert matter; over rocks, stones, wood, metals, and minerals; over all liquid, fluid, and solid bodies; overcome their inertia, and put every form, quality, and condition of them under contribution.

Great things were to be done with organized, but greater with inorganized matter; though man, at the first, little suspected that common things he trod on, and things he passed by daily as of little worth, would become of the first importance to him. The mineral kingdom was to be a special arena of his exploits; in it he was to find materials for his mechanisms, and forces to propel them. As God had imparted motion to animals, so he was to put life, or the activities of life, into dead and shapeless things—to bring forth classes, orders, genera, and species of organisms for himself, such as should take hold of matter like that of which they were made;

knead, mould, and move it as he willed them, and with an accuracy, persistence, and absence of fatigue, surpassing the powers of living laborers.

But can man take pieces of wood and metal; dress combine, and arrange them; place them in positions and locations agreeable to him; tell them to move among themselves, and do his bidding—to card, spin, weave, sew, embroider; plait and knit; crush, grind, and sift; forge this substance into bars, draw that into tubes, spread this into sheets, stamp those into plain and ornamental vases, dress granite into moulded blocks, form it into columns, carve it into statues, and will they obey him? Yes! Every day they are working matter into every desirable consistence and figure, however hard or soft, tough or brittle, dense and massive, or light and fragile it may be. This is subduing the earth; not a part, but the whole.

The extent to which human toil has in this way been relieved, is one of the best things accomplished in the present century. Like every great acquisition, it has cleared the way for others. The machinery just noticed is stationary, its whirring sounds are confined within factory walls, and to it the work must be taken. This is the case with natural motors, except animals. When a horse is released from thrashing grain or grinding corn in a mill, he labors in the field or works on the road. A locomotive power, he goes *to* the work, instead of remaining on one spot, and having it brought to him. Now, could artificial movers be brought out into the open world, run hither and thither, put on the character of docile beasts of draught and burden, the period would be hastened when the power of animals would be laid aside; for it can hardly be questioned that their enslavement was designed to initiate more economic and efficient laborers from the inorganic world.

Well, to some extent this has been effected, and the achievement most honorable to the present age will be felt for good through all succeeding ages. Already, passengers by the thousand, and goods by the hundred tons, are swept along by horses whose food is fire, and whose breath is smoke—travelling equipages that skim over both land and sea with a speed surpassing that of the swiftest racers. And all this done by what? By simple wood and iron, coal and water.

To take advantage of the obvious properties of natural substances required little reflection to suggest, and only ordinary tact to effect; but to conceive and successfully work out the idea of a travelling machine, to build up the thing piece by piece, to screw, bolt, rivet, and otherwise connect its several parts, place the whole on wheels, give it water to drink and fuel to warm it; and then to send it out, the successful pioneer of a new order of perspiring laborers—is invention of the highest type. The production of these moving powers has but commenced, and yet the time appears rushing towards us when the face of the earth will be literally alive with them.

This drawing out of the ground swarms of laborious Cyclops, without limits to their numbers, strength, stature, and obedience, surpasses the legends of Prometheus, Antæus, and Jason. It is the finest proof yet revealed of man's power, and in several respects the most daring and fruitful of his victories. The good to result from it no one can even imagine, so great and so universally diffused it will become. To make things that are unable to stir of themselves active in moving others; to make insensible slaves go and come at our nod; to draw our carriages, plough and reap, fabricate every class of goods, work at home and abroad, indoors and out, to propel our vessels over seas and bring them back, &c., is subduing the earth to an extent that perhaps few commentators on Genesis have contemplated.

CHAPTER IV.

MECHANICAL FORCES AND MEANS TO EMPLOY THEM.

As it is in connexion with mechanical forces that man's conquests over matter will ever appear to the best advantage, let us glance at their development, and at the means of modifying them. They have come gradually upon him, and in a natural sequence; each preparing the way for its successor. Of overpowering influence on his destiny, he has been slow to appreciate them, or to perceive the design of the Creator in supplying him with them. Those easily managed came first, and were succeeded by others that meet higher requirements, and such as called for higher skill successfully to employ them. His first experience is with his own strength, which instinct leads him, in common with the inferior tribes, to exert. How long he applied his hands directly to objects he wished to move, before the lever and other cognate devices occurred to him, we cannot tell; but when he acquired them, he mastered his first great lesson as an incipient engineer.

When a sense of the inadequacy of his personal force began to prevail, animals were first called in; their introduction necessarily involving new mechanical combinations. He could apply his hands directly to a saw, to turn the quern, raise water by means of a pole or pulley; but with quadrupeds the working implements or tools had often, and the mechanisms for communicating the new power to them had always, to be modified. Horses and oxen could readily bear off loads to a distance when laid on their backs, but it was their power to drag, or overcome resistances behind them, that was found most generally beneficial, and to that movement the devices had to be adapted; hence arose sledges and wheel carriages. When continuous efforts in limited spaces were required, then arose the primitive upright revolving shaft, forming the centre of a circle around which the animal travelled, being yoked by a horizontal lever attached to the shaft. In this way the larger quadrupeds were initiated into manufacturing labor, and man himself stepped in some measure out of the traces.

Extending his views, he attempted to make running and falling water work for him, and succeeded. Then he fitted up vanes to catch aerial currents, and laid the fickle wind under contribution. For a century past, steam has done, and is doing, more for him than all other forces. He thus keeps adding to the number, and relinquishes none: hitherto he has rather sought to put each under heavier tasks. The conquest of every new force called for additional intervening mechanisms. Animals brought in novel modes of transmitting power from the mover to the objects moved; water and wind required different ones, while steam and the gases still further multiplied them. Thus every new power called the inventive faculties into fresh channels of thought, excited new aspirations, and opened the way for still further achievements.

But all precious as forces are, they would have been of little worth without *the mechanical powers*, improperly so called. The former are gifts of nature, but the latter were to be discoveries of man's own; and momentous as was to be their influence on his destinies, it is a singular proof of divine provision for educating him as an artisan that they were not difficult to develope. Early reflection suggested, and early experience secured them. Attendants on and exponents of forces, they were to accompany him through his entire career; and certainly, it would be difficult to name an acquisition more essential to his well-being, in any one stage of his existence, from the dawn of civilization to the close of its highest phases.

Means to increase and diminish motion irrespective of that of prime movers, are a *sine quâ non* in the arts. If the world was yet without the six simple machines there could be no manufacturers: mechanical movements could not vary from natural ones, and motors would have to be selected for the rate of their speed as much as for their power. Leaping waterfalls and rushing currents of wind and water could not be applied to delicate and slow operations, nor the requisite velocity of cotton-mill spindles be attained from sluggish first movers. We could not measure time if we had not the means of compelling the seconds-hand of a chronometer to travel sixty times faster than the minute-one, and this as much quicker than the index for hours. Clocks and watches had been impossible things. The spinning-jenny had still retained everywhere one or the other of its eastern or western primordial types—a loaded whirling-stick, suspended by the thread it twisted, or a similar stick spun with the fingers, like a top in a shell. Carving might have been practised, but the lathe had been unknown. There might have been drills, but they would have been those of the savage, whirled between the palms of the hands. There could have been in fact no civilization, as we know there is none, where power to modify motion is not.

The mechanical powers, therefore, serve as *substitutes for a multiplicity of movers* as respects speed; since by them a series of velocities embracing every possible and practical one is attained. But their advantages do not stop here; they also answer the purpose of an *infinite variety of forces;* for by them a force brought to bear on an object is reduced or augmented in intensity to meet every exigence. Thus, by them man's own force overcomes resistances a thousand times too great for the direct application of his strength; and by them he reduces violent and overpowering strains to mild and uniform ones. Two or three sailors can raise the largest ship's anchor, and the marble columns of public edifices are elevated and swung to their places by a few hands at a capstan. The power of an elephant can be made to handle and spin the most delicate fibres, and that of a thousand to fabricate muslin thin as woven air.

By the mechanical powers the cardinal principle of an *interchange between force and motion* is elucidated. By them we can at our pleasure barter power for speed and speed for power; so that wherever there is in a first-mover an excess or a deficiency of either, both are so perfectly subdued that any desirable degree of force or velocity can be drawn from them. A force double the amount necessary to move an object with a certain velocity is made to move it so much quicker; if it be sufficient barely to overcome the resistance, the gearing is reversed, and it performs the work, but takes double or quadruple the time to do it in. By gearing, the speed of a first-mover is increased to any imaginable extent, and reduced to the slowest of perceptible motion. Another point of equal importance is gained by them, the *conversion of one kind of motion into another*;—straight into curved, rectilinear into rotatory, alternating into continuous, direct into oblique, and the reverse of these. Modern machinery abounds with these conversions. Its efficacy depends on them.

I scarcely know anything more wonderful in their effects and more beautifully simple in themselves than the elemental machines, since by them we have *endless gradations of forces and velocities* at our command. Without them the volume of the arts could not have been opened, or, if opened, scarcely one of its problems solved. Could their full value be perceived, they also would serve to warm us into admiration of the Divine economy under which we live, as students of and manipulators in matter.

The simple machines act directly only on solid bodies, but there are forces to be obtained from liquids; not merely from their gravity in weighing down one side of a wheel, or from their momentum sweeping its buckets round, but by their pressure. To render this element available, we should have the means of exchanging speed for intensity, and *vice versâ;* but here wheels and their cognates are inapplicable. To meet the exigence, liquids are subject to a law through which we can control and employ them as motors. Unlike solids, they press equally in every direction, and their pressure is as their height; and hence, as exemplified in the hydrostatic paradox, a quantity of water, however small, can be made to balance another, however large; and as in the hydraulic press, by which a man working a small pump can raise 500 or 1000 tons.

It is the same with elastic fluids. A person blowing through a minute tube may raise tons with his breath; the power of a steam-engine is enlarged or diminished with the area of its piston.

There is, moreover, an analogy between mechanical forces and chemical solutions. The strength of both is weakened by diffusion, and augmented by concentration. The wheel and pinion are to one, what dilution and concentration are to the other. In fine, the laws impressed upon fluids, for the purposes of the arts, and exemplified in the operations of nature, are so admirable, that language cannot express the feelings they awaken in minds that appreciate them.

CHAPTER V.

HINTS TO MAN IN NATURAL MECHANISMS.

It may perhaps be said that though inert matter was made peculiarly subject to man, and ready to receive whatever forms and movements he might wish to give it, some kind of instruction was necessary. A stranger in a strange world, or rather, a new being on a new orb, time was required for him to realize his position and feel his powers. So far as the instincts of his material nature were concerned he was much on a par with the creatures below him; but, as observation and reflection marked his character, he stood in need of information specific and direct. Well, he was not left without it. In the teeming mechanisms working everywhere about him he had illustrations of the principles that govern matter, and of qualities, adaptations, and applications in profusion, to guide him in producing creations of his own. What more could be done for him when every object before him was a lesson? Whenever a stone axe is ploughed up we do not want an ancient Indian to rise out of a mound to tell us what use it was put to. A knife, a pen, or any other manufactured article is a tangible thought, or a congeries of thoughts, in which the mind and workings of the mind of the designer is perceived; and so it is, that the ideas and reasonings, if the terms be allowable, of the Creator stand out in all his works. To those who study his mechanisms, his intentions are as perceptible in forms, motions, and proportions; in levers, joints, valves, tubes, mechanical equivalents, and results; as those of a human engineer in any one of his works.

The great doctrine of form, one of the first, will be one of the last, to engage man's attention. It is taught everywhere by nature. All his first implements and utensils were derived directly from her. In the gourd family he had pitchers, vases, cups, and caldrons ready to his hands, and a thousand hints in other groups. It is conceded that architecture—from huts of bent twigs to palaces supported by single and clustered, twisted and fluted columns—is but an elaboration of natural suggestions. It arose in the forest, and everywhere retains traces in its materials and forms of its origin there.

Whatever amount of credit is due to classic stories about the prototypes of columns and capitals, with their volutes and foliage, in the olive, acanthus, and lotus, this much I can say, from personal observations in a Brazilian forest, that nature has given patterns for such things to an extent that I, at any rate, had not suspected. I met with portraits of the Doric, and in a species of dwarf cocoa with diverging capitals almost fac-similes of ancient Egyptian shafts; others, again, exhibited swellings at their upper parts strongly recalling cognate features in Hindoo structures. But what is the origin of mouldings employed round the bases and other parts of columns? Resting with some companions on a fallen trunk, a singular and most unlooked-for incident arrested my attention, which threw light on that question. I don't know that I was ever so much and so agreeably surprised.

A *sipo* $\frac{3}{4}$ of an inch in diameter (one of the vegetable ropes that everywhere abound) had wound itself several times round the smooth trunk, and had assumed the form of as regular an astragal, or ovolo with fillets, as if made with a plane, except that the square edges of the fillets were rather rounded than sharp. The sipo came down from some lofty foliage, and after coiling round the bole disappeared in the distance. Before it reached the trunk it was of course cylindrical; but where it began to wind, the part in contact with the trunk became flattened, and as it proceeded the yielding cord spread out laterally, forming nuclei and at length perfectly formed fillets. The evolution of these was clearly due to the pressure arising from the tightening (perhaps by drying) of the cord. Where it left the trunk the base of the semicircular profile continued a few feet and then merged into a cylinder. The fillets disappeared earlier.

It will ever be a leading principle in manufactures to put suitable materials into shapes best adapted to the purposes to be accomplished, because the virtue of form does not stop with itself, but extends to everything connected with it. All principles in the arts are allied and run into each other; thus correct contours and proportions lead to economy of material, and this, as exemplified in intermediate and propelling organs, to the least outlay of power; and consequently to the cheapness and durability of machines.

As forms improve, another element, viz. Beauty, begins to appear, the perception of which opens a distinct source of pleasure. It is the proof of excellence in nature, and the reward of it in art. It does not arise solely from what are deemed elegant outlines, but from their accordance with the uses for which the object is made. Without this, the thing would, as a whole, be incongruous and distorted, no matter what conventional taste might approve in its parts. There are no absolute lines of beauty, nor combinations of them; the figure of the most elegant dish could never be graceful in a goblet, nor that of a tray in a caldron, because beauty can never be where adaptation is not. Hogarth's curved line, returning on itself, could have nothing attractive in railroads or the walls of dwellings; with them straight lines are the most seemly, because most efficient. It is therefore on account of the perfect fitness of particular forms to particular purposes, that nature's figures are so diversified and pleasing. Even those from which we shrink would be attractive, did we fully comprehend them. We should then admit that the maternal toad, spider, or crab, might, as justly as Juno, address her offspring as "beauties." Perfection of form is the visible evidence of it in other respects. Man conceals bad work and bad taste under showy exteriors—nature never does.

In the earth's fauna and flora are myriads of forms wholly unknown; only a portion is open to man's ordinary vision, nor can ages of close investigation bring them all out. Of those of insects we know little, of animalcula and the small occupants of the ocean still less. The microscope is constantly revealing new worlds of forms; and it will continue to do so, since there is a universe of them to employ it. What a deep and wide line of distinction there is between vegetable and animal figures, and how inexpressibly diversified are the outlines of each! It has seemed to many, and would seem to all who gave the subject serious attention, an impossibility for a new type to be added, so completely does the ground seem covered; and yet the instant we turn to the mineral kingdom, we find it also has one of its own, with forms varied, till the imagination faints in following them. See the symmetrical figures of which even flakes of snow are composed. It might be inferred that dealers in fancy and ornate goods could not use up the earth's three great books of patterns, if they lived and worked for ever, and took a fresh pattern every day.

But a fourth book has been given us, and it contains as many pages as each of the others. While they are made up of definite and regular configurations, its elements consist of apparently purposeless and amorphous shapes, of random and unmeaning patches, as the streaks and spots on skins of animals, sea-shells, marble, clouds, and flowers; yet in her hands how attractive they are made! *Arrangement* is the kaleidoscope that makes them all symmetrical. Out of twisted, distorted, abnormal elements, it produces figures of perfect forms, while its changes of them eternity cannot exhaust.

Such is the Divine Proprietor's love of the Beautiful, and his desire to cultivate it in us, that he has introduced an adjunct to it in *colors*. With these he has embellished everything on earth, in air, and in water. We tread on a carpet of tapestry the richness of which we do not appreciate, while the canopy over us is an ever changing series of paintings. What pleasures, physical, moral, and intellectual, we had never known if the earth and sky, and all objects between them, had been of a uniform hue! But colors serve more purposes than to please the eye. There shines not a tint on the breast of a thrush, nor a gleam of iridescence on a humming-bird's throat, nor a golden spot on a common trout's body, nor a feather of flame in a flamingo's wing, but has its uses, although naturalists have not yet divined what they are. The summer dresses of arctic animals and birds are regularly thrown off, and winter ones put on; but as yet little progress has been made in the investigation of such matters, and of the laws by which colors are developed and defined, notwithstanding the pleasures and profit the knowledge must bring. To some classes of manufacturers more than to others the study of colors and of symmetrical figures belongs: and what a school of instruction has been opened for them!

Another source of pleasure and of art is opened in sounds. A mercurial workman whistles and sings to break the monotony of toil, and to lighten it, while the phlegmatic diverts himself with scenes in his mental phantasmagoria. What attractive forms are to the eye, modulations and combinations of sounds are to the ear. To vocal, instrumental music succeeded, and became a distinct and popular branch of invention, in which instrument makers have principles and applications of principles in nature to guide them to as great an extent as workmen in other departments of art.

CHAPTER VI.

PROFESSIONS ALLIED TO THE ELABORATION OF MATTER.

Professions seemingly not allied to the manipulating of matter, arise from, and are dependent on it. The diversity of habits and tastes so wisely designed to facilitate the work, is not intended to isolate its parts, but to bring all to bear on each other. Nothing is insulatable in nature or in art. If therefore the great task of man is to imprint knowledge on matter, the labors of scientific as well as of other classes must have reference to it; and they have—they contribute essentially to it. Learned professions are as leaves of a tree; they hang in clusters from kindred twigs and branches that shoot from the manipulating bole, and they aid in the development and ripening of the fruit. The subjects of science are not given to us as pleasing abstractions, but to lead to substantial good. They are charged with practical lessons; and it is the actual employment of the principles they illustrate that is required of us, not fruitless meditation on the wisdom of the Creator, nor barren praises of him. At present, human knowledge exists in scattered fragments. Like uncollected materials for a public edifice, they have to be brought together, dressed, and put in their appropriate places, to form the exterior, and adorn the interior; and not till this is to some extent done, can the true value of each, and the influence of the whole be felt.

Is it asked what scientific men do? Let us see. Physics, in its widest sense, embraces the phenomena of the material creation, and therefore the whole wisdom of God represented in matter. Co-extensive with matter, the science of external things must for ever exercise the investigating powers of intelligences. It is limited in its range on each orb to the phases in which matter exists on each, but, what is very observable, it cannot be prosecuted on one without reference to others, thus reminding us of the unity of creation; that no limb, or member of it, any more than of a plant or insect, exists of or for itself, and consequently that the occupants of all worlds are members of one family, to whom different parts of the family estate have been committed; that all are pupils of one school, though receiving instruction in separate classes.

Astronomers pursue inquiries which some persons imagine have no bearing on human affairs. They are mistaken; so far from being isolated, we should never have so much as seen what our planet is made of, but for the light that streams on it, from one star by day, and from others by night. We should have had no measure for time; and then there is the potent fact, that terrestrial location is only determined by celestial observation, so that we cannot traverse our own earth, know in what direction we may be going, or tell on what part of it we at any time are, without looking to other worlds for the information. Without astronomy there had been no navigation; the seaman deduces the position of his ship from the altitudes and occultations, not only of members of our solar group, but of the fixed stars. Nearly all arts are affected by ocean commerce, while the chemical influences of the sun affect all substances, and almost all processes. Astronomy, then, has a direct bearing on manufactures, from the smallest to the most important articles enumerated in ships' bills of lading.

Terrestrial physics may be comprised in two divisions —one treating of the constituent ingredients of all bodies, the other of their forms, motions, forces, and properties,— *Chemistry* and *Mechanics;* the latter including organic, inorganic, and artificial mechanisms, or those made by God and those formed by man.

Chemists have more richly contributed to the arts than other savants, because more intimately employed on matter. For one great fact we are indebted to them, viz. the compound nature of all bodies—that minerals and vegetables, solids, liquids, and the air itself are all alloys —that forms, qualities, and colors are results of proportions of composing elements. It is extremely probable that no simple form, or true element of matter, has yet been ascertained. In furnishing new compounds, chemistry has marked the present times as an era in the manipulating arts: while many depend wholly upon it, its influence extends through all—there are no imaginable limits to the number and value of its contributions. The next popular prime-mover is certainly to come from it.

Naturalists, so called, divide themselves into classes corresponding with the objects they study, as plants, fishes, reptiles, insects, birds, mammalia, &c., in which the Great Artificer has given examples of every variety of motion, of transmitting and compensating mechanisms, of adaptations of parts to a whole, of form to speed, and other results; of harmoniously working and absolutely perfect machines. Human arts have at length arrived at a point where consulting with those of nature has become more than ever necessary. In the contours and movements of organs of locomotion, in the feet and wings of insects and birds, of reptiles and fish, much has to be observed, more than the highest order of minds can exhaust in any age. In the structures raised by insects, birds, and some quadrupeds, and in the fabrics many of them make, the most perfect application of mechanical principles, with economy of material, is displayed. So also in their manipulating apparatus and processes, in their weapons of attack and defence, devices for ensnaring game, &c., &c. All is literal chemistry and mechanics, and will be full of instruction to artificers for ever.

When marine engineers, for example, comprehend the principles that govern the movements and velocity of water animals, from the jelly-fish, progressing by collapsing and expanding itself, to the gambolling flying-fish, and the meteor-flight of the sword-fish, they will no longer be at a loss respecting the figures and action of their propelling blades. The prolific provision, the wonderful varieties of principles and processes for the locomotion of marine bodies, and bodies of every form, from the gangliated medusæ to the dolphin or other swift swimmers, and for movements in every possible direction that necessity, pleasure, or even sport requires, is enough to fill every soul with delight. Besides mechanical, there are chemical lessons for boat-builders, *e. g.*—Instead of covering the bottoms of their fast vessels with grease that repels water, and thereby retards their progress, they would seek for a coating analogous to that of fishes, which, while impervious to, coalesces with the fluid, and consequently enables them to move more readily through it.

As with the vegetable and animal, so with the inorganic world: all the operations going on in it are solutions of mechanical, engineering, and chemical problems. Natural philosophers amuse themselves in the kingdoms of nature, without apparently being aware, and certainly without being fully aware, that everything they see is or will be applicable to devices which progressive civilization will demand. But our age, like lower epochs of geologists, is preliminary to and prophetic of a superior future.

From the foregoing rapid views of the earth, her materials and forces, and of man's organization and achievements, it is impossible not to acknowledge the adaptation of one to the other, and not to feel that all things accord with his duties as an artificer; that he was created to excel as one—that the business of his race was and is to take the products of nature's mills, and, by further elaborating them in his own, to bring out in endless succession beneficial results—that he was to collect natural motors, contrive artificially excited ones, and make each the centre of moving mechanisms for shaping matter into newer and newer forms of utility and beauty—to cover the earth with barns, workshops and dwellings, roads and canals, and the seas and rivers with his ships—to produce goods and merchandise for universal commerce—to banish idleness and want with their concomitants, by diffusing industry, intelligence, and competence through every community—in a word, to become in its widest sense a manufacturer.

It is, however, true that as Lord of the earth, man as yet has no adequate conception of his high destiny. A little light flickers here and there, and it is spreading, but nothing compared to a general illumination. The conviction is not fastened in him that he is placed here in charge of an establishment teeming with treasure, to add to a capital that can only cease to increase by his ceasing to employ it, and that if he suffer it to lie idle, no power on earth or heaven can use it for him; that it is in nature as in grace—to him that makes the most of what he has more shall be given, and he shall have abundance, while from the indolent shall be taken that which he hath—a civil, political, and moral principle, of which the history of nations is, and ever will be, a running commentary. No useful and productive thought should be confined to the mind that conceives it, nor can it be, without incurring the guilt of Achan.

The truth, however, is dawning; advanced ideas are obtaining; ancient boundaries of thought are giving way, and new views of man's capacities and powers arising in the widening horizon. To one great lesson the world is beginning to listen: *Faith in human power.* The truth it enforces is all potent for good. Before it, every obstacle must eventually give way, and to it every element and influence in nature will be subject. As a cloud is the "mother of rain," so is this faith charged with more refreshing showers than have yet fallen on our species. Emerging from dark times, it is but recently that the power in man has been suspected. The subjugation of steam, electricity, and other agents, points to the divinity within him, and fortifies the doctrine that "all power" on earth is committed to him—that on himself alone it depends whether he be omnipotent here or an imbecile. Hence, where this fundamental truth is not taught, men are children; where received, increasing elevation of character becomes manifest. And what is there, with reliance on himself, that man cannot do? Till modern times, he has been struggling in uncertainty, scarcely knowing what to hope for, nor what was lawful to attempt; but now, with a little faith, he is achieving the greatest things and successfully wielding nature's mightiest forces. Except interfering with its movements in the fields of space he can make this orb pretty much what he pleases. Here are none to trouble him, no interference from without or within. Shut up in his floating homestead, he has ample means to improve it, and make both it and himself what both were created to be. Its climates and aspects he is changing, and it is certain that whatever he makes it, it will be a type of himself—of the range and vigor of his energies, or of intellect impoverished and matted with weeds.

CHAPTER VII.

OBJECTIONS CONSIDERED.

There are two objections, or what may be construed into objections, to the theory of man's earthly business being that of an enlightened elaborator. 1. It may be urged that if the theory be true, more and better work would have been done, had men been united under one civil and political rule, instead of being divided into multitudes of unequal and jarring communities. A central power could have drawn forth and profitably directed the energies of the whole, in place of their being frittered away in isolated efforts. The answer to this is, that the scheme is impossible, physically and morally; and further, if it were practicable it would be productive of no good, as long as the earth retains her present organization and the human family is made up of such diverse progenies. People of the tropics can never be the same in temperament, tastes, habits of thought and feeling with those of the middle zones, nor these with occupants of the coldest circles. All men could not be included in one civil polity. *E pluribus unum* is nature's motto, but not in all the senses some would have it.

We are sure, whether the causes are obvious or not, that the progress of science and art is furthered by the separation of men into national groups, and that to compress the dissimilar materials into one mould would be fatal to all. As observable in peoples who shut themselves up from the rest of the world, individual activities would settle down and be merged in universal heaviness, if not torpor; the general mind would become stationary, and advancement be impossible. The species would form one family, but it would be a family of Chinamen; and it would remain one, since there would be no outside Fanquis to break up its stereotyped ideas and put them, with others, into new and better combinations. The law that elicits light by the collision of mind with mind is as necessary to prevent mental and material stagnation in nations as in individuals.

2. The second objection is based on what certainly does retard progress, since it obstructs both the freedom and cordiality of intercourse, viz. the complexities and multiplicities of language. How did this grave impediment to the interchange of thought arise, and how long and to what extent is it to endure? Is it the expression of an organic law, or is it due to local and fleeting causes, and fated to diminish or disappear with them? It is reasonable to infer that if the earth was designed for a manufactory, and a mart for exchange, provision would have been made for facile communion by both oral and written language; and that if obstacles were unavoidable in the early days of the establishment, from the operatives being scattered over the earth's great provinces, yet as the knowledge of its resources became general, and man everywhere sought to correspond with his brother man, the confusion of tongues would in a great measure cease. We believe it will.

Language and its origin have been descanted on as miraculous and mysterious. So they are, but not more so than other natural phenomena: *e. g.* the languages, if they may be so called, of the lower tribes. Of these, every species has its own mode of communing with its kind, and hosts of them by articulate sounds which in birds apparently exhibit as great a variety of tones and inflexions as is within the compass of the human voice. But animals make no additions to their speech! True, because they make none to their arts. Their means of communication are commensurate with these, and hence more would have been superfluous. Had the inferior tribes been ordained to evolve novel processes of elaboration, and new forms into which to work matter, their perceptive and expressive organs had necessarily been expanded. Every man's language is confined within the circle of his knowledge, but then he is intended to enlarge that circle.

This distinguishing feature between man and the creatures below him has led many writers to contend that a progressive order of beings differs so much from those that are stationary, that while the laws which governed the creation of the latter sufficed from the beginning to meet all subsequent exigences, those of the former were insufficient; and hence, by a series of special interpositions of the Creator, man is thought to have been instructed in the elements of language and of the arts. These teachings are supposed to have been continued down to the erection of the tower of Babel. Speaking of that structure, a recent writer observes:—"We have now reached the point where human civilization in its collective form ceases to depend on the direct interposition of Omnipotence, and where the elements bestowed by the Creator are left for their development to human ingenuity and human industry."*

Readiness to recognise the Creator in his works is the characteristic of every enlightened mind. He is blind and deserving of pity who does not perceive the All-Pervading Intelligence, Beneficence, and Power; but it does not follow that he is a sceptic, or undevout, because he

* The Natural History of Society, by W. C. Taylor, LL.D., of Trinity College, Dublin. New York. 1841. Vol. i., p. 305.

does not see those special interferences or the necessity for them. If he acknowledges the Creator as accomplishing all things by laws enacted by Him, he is as faithful, and, as we believe, acceptable a believer as any who advocate particular interpositions, and therefore admit imperfections of those laws. One is devout without philosophy, the other with it.

Primordial influences imparted to animate and inanimate matter are as impressive and active as ever they were. As regards speech, oral and written language consists of words, and the invention of words goes on now as at the beginning, and as it will go on to the end, for there can no more be a language than an art that is not capable of expansion. Whenever a strange animal, bird, mineral, or aught else, occurs to an Indian of America or Australia, he gives a name to it; one more or less characteristic, and serving to distinguish it to himself and his people. Just so it is with civilized man: the arts have called and are daily calling for new words to designate novel materials, forms, colors, and qualities, while naturalists, chemists, and others are coining them by scores to represent and express new discoveries.

Indeed, it appears as obvious as any analogous matter can be, that man was as well qualified at his creation to develop and work out the earthly destiny for which his organization expressly fitted him as animals were to work out theirs. If either stood in need of extraordinary direction, one would suppose it would be the least intelligent. But supposing particular instruction was necessary to induct him in the first form of speech, which from the paucity of his ideas (the case wherever the arts are not) must have been exceedingly limited in its scope and application, was not an equal or greater amount of aid requisite to originate and mature among his descendants a thousand forms more comprehensive and expressive? It is as wonderful indefinitely to diversify and extend a principle as to unfold it—to construct a steam-engine as first to raise steam in a skillet.

The same principles that originated language and arts led to their varieties, and it did this whether mankind was originally of one family or not. If they were one, their speech was confined to what they knew while they remained together, and assuredly their knowledge then was almost nothing, compared to that which the species was to attain. As therefore the largest portion of man's ideas, and of words to express them, had to be acquired after his dispersion over the earth, the process of their development would be the same, or about the same, as if there had been several original centres of populations. Things peculiar to one climate were named by those who became familiar with them, but neither the names nor the things could be apprehended by those who never heard of either. Thus, a succession of new objects, impressions, and perceptions arose, as men passed from one latitude to another, and unavoidably gave birth to local languages, which time rendered more and more distinct. Inhabitants of islands and sea-shores had one, necessarily unintelligible to people that never saw the ocean, or a fish. Moreover, things common to distant countries could rarely be called by the same name, because they do not make the same impression on all minds.

Languages are unstable. They are ever changing.

Most of those spoken in the first ages are wholly lost, and of such as are now spoken, numbers are dying out. The legions of aboriginal tongues of this hemisphere, and of Australia, Oceanica, of large portions of Asia and Africa, are being slowly but surely superseded by those of the French and English chiefly. Why is this? Because language is the instrument or exponent of the arts. If it is the prime business of man to cultivate them, it is one of the chief purposes of language to circulate the knowledge of them. Hence, where they progress it flourisheth, and where they wither it deteriorates. Past history sufficiently pointed out, but modern annals proclaim aloud the truth, that henceforth nations, kindred, tongues, and people, can endure only as long as they are identified with the expansion of the arts. We therefore hold that the embarrassments to the circulation of knowledge arising from the multiplicity of tongues, belong to an incipient condition of man's career, and will, in a great measure, disappear as he advances.

SECTION III.

MISTAKEN VIEWS OF MATTER, AND OF MAN AS AN ARTISAN; WITH THOUGHTS ON THE UNIVERSE OF MATTER.

CHAPTER I.

ENEMIES OF MATERIAL AND MORAL PROGRESS.

THERE are two classes whose mistaken views have tended to retard material and consequently moral progress; one, influenced by sickly and depreciating notions of the material world, for with them spiritual things are all in all; the other by conventional standards of gentility. The former think they please heaven by casting matter behind them; the latter please themselves by treading on it in preference to working in it. A principle of vanity governs both, and leads them to violate, as far as they can, a fundamental law of their being. Happily the influence of both is waning.

In assigning this earthly establishment to the charge of man, God inserted in the "Deed of Trust," a condition on the part of the lessee, which defined the character he was to put on, and the career he was to run—a condition which he was abundantly able and specially qualified to meet. It was this: Materials were to be found him, but he was to find LABOR. This was to be his portion of the working capital. On the other hand, no restrictions were laid on his undertakings, and the entire profits were to be his own, so that prosperity and every degree of it were to rest with himself. No natural truth is more luminous and patent than this. It is written on every leaf of creation, and stamped on every human faculty, that man was to be "a child of labor"—that for it he was made, and sent hither.

Hence there is nothing here to encourage the absorption of life in spiritual thought. The mind is to be active, and active on something else than itself and for itself. Those who have no sympathy with things here, have no business here. It is in vain to create and decorate worlds for them. To float in some dreary corner of the abyss, out of sight of any orb, would answer their purposes better, since no object would then be near to break their meditations. The idea of this sphere being an inn to give a few nights' lodgings to travellers passing hastily over it, the object of whose journeying is too high and urgent to allow them to examine or care for its conveniences—whence could it have proceeded, but from the weakness that leads men to magnify their vocations, and infer thence their own importance? Such are the absurdities into which those fall who attempt to separate what God hath everywhere united—matter and mind; who insanely dream of pleasing him, by debasing one and exalting the other.

Man is to be no spectral recluse, dozing away life over legends and relics; soddening his soul to the condition of a mollusk, and limiting his views of the world, like those of an oyster, to his cell; leaving the earth to grow up a jungle, and his thews and sinews to wither for want of employment. No! He is to be no dreamer in-doors, but an active, vigorous, and refreshing thinker and worker without. How awful, then, is the delusion, which from the earliest period has made the finest portions of the earth mental deserts and the scenes of recurring famines! Monasticism has flooded them with "Palmer-worms," and wherever these have been, and wherever they are, to use the words of a prophet, "the land mourneth."

In Protestant countries the pagan delusion, where not eradicated, is held in check, but in them much of the old leaven of mysticism remains. The true dignity of labor and its influence on morals and religion are but partially felt. Doubts and fears prevail as to the degree of estimation in which science and arts should be held. With some to magnify matter, to anticipate the highest phases of civilization from its developments, is making far too much of it, rendering men too earthly-minded, and inducing indifference to the things of a better life! As if the fervent improvement of an earthly homestead was incompatible with the appreciation of a heavenly one. They concede that working in matter was to be a feature in man's character, but not the most marked one, not THE one for which he and the earth were made precisely what they are. That God had no higher purpose in our physical formation than to make us artisans, some cannot endure. Their ideas of and reverence for him are offended at it. With them matter is an encumbrance on the spirit, and evil associated with it; hence they deem it a duty to hold themselves as loosely connected with it as possible.

Such are the views and feelings of sincere, but minutely devout persons. They have not the remotest idea that profound knowledge and therefore profound love of the works of the Creator, with increasing applications of science to the arts, must be combined with true religion and form an important element of it—that the natural eye must be kept wide open as the eye of faith. All who seriously suppose the association of man's immortal powers with perishing matter derogatory, should tell us by what else the soul can be instructed. They long for something better, something purer, something they know not what, and which they certainly cannot have; because there can be nothing, imaginable or unimaginable, so well adapted to discipline the highest faculties of our nature. If there had been, it had been given us.

There wants an angel's shriek in the ears of these men to startle them from their dreamings and awaken them to the value of the privileges of looking on, studying, and handling that of which God has moulded the heavens and the earth, by which he educates the intelligences of all worlds, and through which he proclaims his universal purposes and power. What is matter? Who can tell? No finite beings can say what its nature is. We only know that it is prolific of wonders. It is the mirror of the Creator's attributes, the seed of his beneficence, the agent of his providence; the visible, tangible, and grandest proof of his existence.

The study of it exalts and adorns every Christian virtue. It expands all minds, and as they expand fills them to overflowing with the sublimest views of the Author of the universe. It draws them into communion with him and moves them to pity those who, from mistaken ideas of him, pass through life regardless of his works. And it makes them shudder at the grossness of much of the worship offered him—as if He were to be complimented, like a weak-minded mortal, with pæans of professional songsters, histrionic costumes, and genuflexions, bijouterie, and baubles. All past and not a little of current history presents a picture of intellect thus smothered, and of physical energies thus shackled. We need look no further than this hemisphere. In the southern half, it has been and still is, made the *chief* business of the people to carry on what they are taught to believe is a holy war; and with the view of prosecuting it successfully, to keep up a perpetual series of verbal flatteries, and requests addressed to swarms of dead men and women, who when living never heard of either them or their country. Now what have been the attainments of one of the finest branches of the human family under such a regime? Where are their arts, literature, and science? Have they for three centuries contributed aught towards human progress? Verily, man *has* something else to do here than fighting under sacerdotal leaders for church systems and formulas.

The souls of nations wither in philosophical and religious dogmas and abstractions. The visions of Indian and other Fakirs have entailed mental and material destitution and imbecility on a large part of the earth. But a change has to come, and will come, over men's minds respecting the relationship of matter to the intellect and morals. Every day is adding force to the doctrine that the emancipation of the soul is inseparably connected with progress in the arts, and that it never has and never can outrun them.

But arrogance is not confined to one class. There are other classes—those who also imagine themselves the earth's caryatides—who think it is their heads and hands that keep the heavens from falling. Of these are many who despise manual labor, and hold themselves superior to those that practise it. With them society should always retain its past resemblance to a living pyramid—one class standing on the shoulders of another, each lighter and less numerous, up to one or two posture-makers at the top, the largest class at the base being the least regarded, although the entire superstructure rests on them, and its stability too.

But in spite of the general discredit, not to say odium, attached to manipulating labor, necessity led to an exception in favor of agriculture. A powerful element bearing on their interests, old statesmen wisely magnified it, and thus it has continued to be a staple theme for orators and poets to descant on. Great men applaud it, and it is honorable; while other departments of industry, implying, to say the least, equal knowledge and skill, not having been thus patronized, are still associated with ideas of something low and vulgar. But for this it had always been deemed as respectable to invent a plough as to use it, to construct a carriage as to ride in one. There is perhaps nothing more strongly indicative of the present being an early stage of man's career, than the prevalence of the barbarous sentiment that associates meanness with labor, that holds it inconsistent with dignity, and even respectability. Hence the doctrine that man was created a manufacturer scandalizes those "respectable families" who pride themselves on being something better, and distresses small-minded individuals, who, accidentally elevated to high places, twinge at the remembrance of having once labored for a living with their hands.

Ashamed to work in matter! Why, if we may speculate on the future, it may well be that few things will afford greater surprise to other orders of intelligences, than that we, minikin occupants of a globule, compared to some orbs, should, in our transcendent pride and impertinence, have deemed manipulating in it disreputable! and some rejoicing in the hope of death releasing them from further contact with it—from that which is everywhere showing forth the glory of God, and everywhere obeying him! To such minds it would be blasphemous to describe the material universe as a host of locomotive carriages, of which suns are furnaces and engines, and planets passenger-cars and tenders.

The sentiment may now be passed over as a harmless error; but it is in fact one which has been the great bane of human progress in all ages. The old Greeks and Romans have not been surpassed, if equalled, in poetry, painting, sculpture, and other "fine" arts; had they cultivated with equal ardor the useful arts, they might have realized steamers, railroads, gas-lights, and all the great modern agents of civilization, and continued down to our times with increasing power and glory. But they committed the fatal error of older people, of classing mechanical professions under the general designation of "*servile,*" and consigning them to slaves—thus adopting the most infallible means to arrest improvement, and insure their own national decadence and death. That the prosperity and duration of nations depend on the increasing applications of science to the arts, is *the* lesson, which, above all others, history teaches; and strange to say, most nations have yet to learn it. There is not one, and there cannot be one, more vital to humanity; nor is there one, the neglect of which has been so uniformly and so fearfully punished.

Prevailing ideas of labor are necessarily crude, because it is viewed only in its earliest and hence in its coarsest aspects. We live at too early a period of its development to witness, or perhaps to appreciate, its highest phases of refinement and results. When it becomes everywhere combined with a knowledge of the principles it is designed to invoke and apply, it will be prosecuted with pleasure and impart a healthful vigor to both body and mind. As man progresses the lowering clouds now hanging over it will, one by one, break away, and let in light and radiance. A chief means by which this will be brought about is already observable in the effect produced by inorganic motors. To the energy in these there are no assignable limits: they are incontestable proofs that man is not designed for a drudge, for as they are increased he exercises his mental powers more, and those of his muscles less, while the amount of work and its products are indefinitely augmented.

CHAPTER II.

THE DIVINE CHARACTER DISPLAYED IN NATURAL MECHANISM.

LEADING traits of character are discernible in the labors of animals. We discover what may be called the turn of thought of the beaver in the construction of his dam, of the bee in its cell, of the spider in its web, and the bent of human genius in human arts. So it is with the works of the Creator. It has pleased him to display his attributes in material mechanism; to fill the heavens with it, and to furnish us with specimens in this earth. We find everything in it and on it made up of the same elements that carpenters, smiths, and other artificers work in, and its motions and forces literal as those of a water-wheel or steam-engine. It is, moreover, prepared as a special theatre for artificial mechanisms, on the development of which the welfare of our species is made to depend. His character as a mechanician is therefore pre-eminently in accord with his works, and in his making it the first and last duty of man to excel as one—*i. e.* to imitate him. "Architect" and "Architecture of the Heavens" are terms mostly used because more in unison with current ideas of respectability; but they are improper, since the impression they convey is not a correct one. With the works of architects, as a house, a bridge, &c., we necessarily associate ideas of fixedness and immobility, while motion and change of place are essential characteristics of the universe. It is a display of forces and motions—there is nothing in it at rest.

The idea that there is neither as much nor as high an order of thought expended in the operative arts as in law, medicine, divinity, and other "professions," and that its effects on the intellectual and moral world are less and less beneficial, is erroneous in every particular. Examine it thoroughly, and the converse of the proposition will be found unmistakably true. Glance over both land and water, and behold what manipulators have done, and for a summary of present results visit the "Exhibition of the Industry of all Nations," and observe there how physical become moral blessings; how the understanding and the heart improve with the cultivation of matter; what health-giving, soul-elevating, and heaven-inspiring properties it has, and then say, as some do, "where the hands work the brain is dormant."

The "fine arts" were worshipped of old, and modern amateurs are at a loss for language to express the depth of their devotion to what they call the product of the imagination and taste, in contradistinction to the "industrial arts," which are said to depend more on the hand than the head. The sentiment belongs to an incipient rather than to an advanced stage in human education, for as science progresses the artificer originates and embodies more thrilling and sublime conceptions than were ever portrayed by the crayon. Then some of these, at least, are to be absorbed by the mechanic arts. Embroidery, the employment of ladies of taste from the time of Penelope of Ithaca to ours, is now done by machinery. The painter's brush and engraver's burin are being superseded by chemical manipulations. Books will soon be illustrated, as portfolios are being enriched, with photographic pictures, which, for correctness and fulness of outline, depth and delicacy of shading, minuteness of finish, and effect, no artist can begin to rival. The great problem of Engraving by the agency of light is also solved, so that the graver, like the needle, will become in a great degree a thing of the past.

But does not this exaltation of matter tend to resolve life and consciousness into it? No. There may be mind without matter, but there can be no matter without mind, neither form, color, quality, nor quantity. We view natural productions as the immediate result of influences in active operation in nature, and the achievements of man in the arts as the effect of forces upon inert substances; but these forces, whether organic or inorganic, are valueless as motors unless subject to another kind of power—THE POWER OF THOUGHT. This, in truth, is the only Prime Mover. From it all creations, human and divine, proceed, and hence the material everywhere refers to the immaterial. It is thus we learn that not only knowledge is power, but that there can be no power—no physical power—without it; that all material are resolvable into mental forces; that worlds were made for the cultivation of intellect; and that the streams of knowledge circulating through them flow from the mind of Him whose hands formed them all. A ship is not a stronger proof of the existence and intelligence of man than is an animal or a plant of those of God.

Matter is the day-book in which man's accounts are recorded : all knowledge is directly or indirectly written on it. There is in fact a mathematical relationship, or something like it, between elaborated matter and mind, so that the amount of the latter can be deduced from the former; for every object of art is the repository or representative of a certain amount of thought, and so is every crop a planter reaps, and everything else on which mind has been expended. The industry of an age or of a people is as the vegetable and animal products they grow and minerals they raise, while their position on the scale of progress is marked by the elaboration they give to those substances, and the uses they make of them. Had we statistics of the Past to compare with those of the Present, a constant relationship would be found to subsist between the mass of matter manipulated in any given period and the sum of contemporaneous knowledge.

Those who depreciate matter know not what they owe it. They view it regardless of the mind, the infinity of mind, that pervades it. They forget that it is the agent of thought; that every object in nature is a visible, stereotyped truth, just as in the world of art a saw, a nail, or a printing-press is another; that man, like his Creator, makes matter not only the recipient of thoughts, but sends it forth a missionary to circulate them. Take away all our ideas that emanate from and are allied to matter, and how few would be left! Our minds would be nearly blanks. This is not a world for the cultivation of thought in the abstract, *i. e.* of purely intellectual conceptions. There are few such, and few minds to pursue them, while those flowing from outward things are exhaustless in variety, attraction, and value. Matter is the universal teacher and preacher. It has broken no laws, it sanctions no disputes, but silently exhibits its doctrines, which no one can interpolate or corrupt, with illustrations infinitely diversified from day to day. All its manifestations, from a snowdrop to a world, exclaim, "The hand that made us is Divine."

There are great sermons in occupations and trades (but few are preached), based as they are on the physical embodiments of Divine wisdom, and embracing all the miracles of science and art. They show how the original precept given to the head of our race, to bend the things of nature to the purposes of improvement, strengthens, when carried out, every social, moral, and religious sentiment. Why, then, not teach that there is a Divinity in every particle of matter, in the commonest; that laboring in it, so far from being profane, is a sacred work; that those who draw active forces from it are not simply doing the will of God, but are engaged in one of the noblest tasks enjoined by him on our species. Why not enforce more, the first and great commandment in the midst of such prevailing heresies respecting it, and strive to annihilate the spirit of lay sect, or caste, that has so long marred the old gospel—presuming that God, like some of us, smiles more on some divisions of laborers than on others, and most of all on men who labor not at all.

The popular absurdity that labor was imposed as a punishment receives no sanction from the Scriptures—not a particle. The original and all-comprehending injunction, "replenish the earth and subdue it," was given before "the fall." In it, the true relationship of man to the earth, and the business of his life, are compressed in half-a-dozen words. On agriculture and the arts his powers, mental and physical, were to be concentrated. No intimation of limits to his progress in them is conveyed. They were the germs from which his prosperity was to arise, and from their ever-growing developments the ripest fruits were to be gathered. Nothing else is mentioned, because all things else were to arise from and centre in them.

To work, in one way or another, for a living, is a necessity with all creatures, but then it is associated with and made conducive to pleasure. To renew their exhausted strength, food and rest are requisite; and these the Creator has, in his benevolence, made sources of enjoyment. Then, relaxation is essential; and who has not observed how conspicuous is the enlivening of labor with recreations and diversions! Birds interrupt the toil of building nests and collecting food with their carols; and all animated tribes have their seasons of buoyancy and joy.

Were two strangers from another planet to take a stand outside of our globe and contemplate, as it turned on its axis before them, the operations kept up on its surface by battalions of working men, the changes matter undergoes in their hands, the employment it affords for every variety of mental and physical organization, the diversity of talents and tastes it elicits, the learning and science it fosters; the individual, social, national, and mundane blessings it confers and leads to; and were they to observe how earnest and constant nature is in bringing it into conditions suitable for those artists to take it up; could they resist the conviction that the earth is a divinely appointed school for manipulating in matter, and that man's highest destinies must depend on the expenditure of deep thought and intelligent labor upon it? After noting the divisions of labor current with us, and the contributions of each of the great classes into which society is divided, would they be led to award honor according to the rules of court heralds?

Suppose they came as delegates from a newly formed orb, to make themselves acquainted with the progress we had made and the manner of it, and to engage a class of men to introduce our best things to their people, they would of course be invited to step into the Crystal Palace, and there see how far we had succeeded in rivalling nature in the diversity, elegance, utility, and beneficence of our productions. Would they, after consulting together, ask for a corps of statesmen to return with them, or of warriors, lawyers, or poets; or would they not ask for a company of scientific artificers of men who not only study principles, but fulfil the purpose of the Creator in ordaining principles by applying them to the prime elements of mental and material elevation?

Whatever may be the nature and occupations of a future existence, or the influence of the present life upon it, the professional character of man here, as drawn from his general employment, and the general result of that employment, is, and must always be, that which has been named. To work in matter, to put up his sleeves, handle and elaborate it, to bring all the powers of his mind to bear on it, is his earthly business; and we may be very sure that it cannot conflict with his future employments—nay, that it must be eminently conducive to them. To be satisfied of this we need only look at the acquisitions he has made in it, and compare them with those of non-working, non-inventing tribes, and observe their effects on society—that where they are, men are more kind, charitable, forbearing, intelligent, and religious than where they are not. And how can it be otherwise! Should not those who study and employ themselves on that which God has adopted for the universal manifestation of Himself—that on which he imprints his thoughts, and everywhere clothes his conceptions—be wiser and better than those who disdain it. Forming the first course of studies and discipline of immortals, it may, for aught we know, be the subject of all succeeding courses. There are doubtless mysteries in it which eternity will not suffice to reveal. Its properties are probably as numerous as the permutation of its atoms. Were not everlasting good to be derived from it, the universe had not been made of it, nor the occupants of the universe been put apprentices to work in it. Neither philosophy nor the scriptures affirm that any intelligences exist who have not acquired their knowledge through it.

When the value of the lessons laid up in matter begins to be understood, and the supremacy of labor to be acknowledged, there will no longer be a shrinking from dilating upon them. Christian ministers and moralists will dwell, and delightedly dwell, on the character of THE MECHANICIAN which the Creator has chosen not in one, but in all orbs to appear in. They will perceive divine revelations in principles of science, and enforce their applications in the arts as essential to spiritual elevation. They will recognise in the "Mechanical Powers" a table of laws written by the finger of God, and admit the inspiration of modern as of ancient engineers. They will teach that God is as near to us, communes as directly with us, in the doctrines of physics as in disputed creeds, ceremonies, and forms of faith; that in science and art no discoverer lives to himself; and that as every one is to be rewarded according to his works, those who have been useful in advancing the arts of industry and peace will not be overlooked; nay, that God will welcome them, and bid those who passively or proudly floated on the tides and currents of life to stand aside and make way for them.

CHAPTER III.

THE UNIVERSE OF MATTER AND OF MECHANISM.

It is marvellous that any created being should be able to study its own organization, and reason on the causes and modes of its existence; that man, a piece of animated matter, should pry into his own structure, and, by dissecting the bodies of his fellows, find out the reasons that determined the forms and proportions of his own organs; and that he should then turn from himself and inquire into the nature and attributes of the Author of his being! The wonder is not greater than if balls of clay in the hands of a potter should ask "What doest thou?" or if spinning-jennies and power-looms were to pause in their movements to inquire why they were made. Man is a tissue of marvels; his little seething brain, as if a part of the Godhead were located in it, spurns at boundaries to his thoughts. He neither confines them to the world he occupies nor to the visible heavens, but urges them through the invisible depths of space to learn, if possible, what is doing there. Nor is this all: not content with employing them on things of the present, he sends them into the future, and exercises them on the past. He is told, that in the beginning God created the heavens and the earth; but he longs to know how they were produced—by what principles and processes they were developed and are sustained.

That this amazing faculty is given for the great purposes of his education, it were a truism to assert; more than anything else it shows how illimitable are the soul's aspirations. As for imaginings of what was before the sidereal heavens appeared, they can hardly be carried further than a supposed condition of things, which may be illustrated by a discovery made some years ago of a subterranean structure, of unknown origin and antiquity. The proprietor entered with a light; his voice reverberated along the arches, and the dark and silent chambers were instantly charged with clouds of dancing atoms awakened into motion by his presence. So, it has been suggested, was the cold and boundless abyss first charged by the voice of God with the dust of which stars are made.

Wherever matter is, it proclaims the Builder of the universe, and discloses more or less of his plans. But why was it produced at all, since he requires for himself no visible or tangible manifestations of his ideas, nor any such means to record or peruse them? It arose then for some other purpose, and what was that? Surely, that it might be an arena for sensitive beings. From pure beneficence creation came; beneficence, whose essence is expansion; which ceases to be when it ceases to dilate, which cannot be confined in the breast even of the Deity. Through it the universe is working out the divinest of problems—the diffusion of the largest amount and diversity of enjoyment among the greatest variety of recipients. Hence, every form that matter here puts on, every condition and change of condition in it, is made an occasion to introduce fresh beings to disport themselves in the varying media. In this view, how admirable is the principle of limiting life, that legions enjoying it may be multiplied till they equal or surpass the atoms of which worlds are composed! Every particle of matter is the agent and symbol of enjoyment.

Is it any wonder, then, that space is swarming with worlds; and that vast as our field of view is, it takes up no more room compared to the whole, than does an insect in our atmosphere? Suppose the universe had been altogether inorganic, without a pulse beating in it, or an eye to glance over it, would it not have been a fruitless display of Almighty power? But how different the reality! Instead of existing alone, wrapped up in his own felicity and perfections, He has made matter the agent of eternally diffusing both.

What the future destiny of the myriads of floating worlds and their populations is to be, no one can tell, nor why the Almighty adopted the existing plan of the universe. It is enough for us to know that he created matter, and everywhere appears as The Great Artificer in it; that he has ordained an essential intimacy between it and finite intelligences; commences their being with it; makes it the medium for the development, expansion, and employment of thought, by transfusing his wisdom through it, and making it their duty to seek that wisdom out—*i. e.* to discover the laws impressed on it, and by acting in accordance with them, to evolve from it all sciences and arts.

Is it asked why He has not gathered matter into a single orb, and made it the ONE abode of physical beings, instead of dividing it into innumerable and varying volumes, and so widely separating them as to exclude all intercourse between their occupants? 1. Perhaps, because all matter would then have subsisted under the same conditions, while its developments would have been confined to those conditions. Creation would have been after one pattern. 2. Because only a very superficial portion of matter could have been brought under observation and control; almost the whole would have been locked up in subterranean depths, which no finite minds could fathom, and out of which no finite powers could withdraw it. Were physical intelligences *not* created to be elaborators of matter, the plan might have been adopted; but if they were everywhere to grow up with it, if their duties and destinies were inseparably associated with it, then it was necessary that it should be made accessible; and how beautifully this is accomplished by breaking it up into large and small bodies, arranging them in groups, launching them into the utmost boundaries of space, lighting up the whole, and thronging all with operatives adapted to the work to be done on each! By this plan the conditions under which the material of the universe subsists, are infinitely more diversified than if collected in one orb, and consequently its developments also.

How wise, then, and how good in thus spreading abroad this most miraculous, and eternally incomprehensible agent of Himself in portions suitable for finite intelligences to explore! And then is it not well that the occupants are confined to their respective locations? Were they at liberty to pass from one orb to another their physical organization would be unequal to the change, while, from the widely different conditions under which matter exists, what they found new abroad would be inapplicable at home. Though an interchange of ideas with operatives of other planets would be of surpassing interest, it could lead to no very marked advance of the arts in any of them, for the reason just named. As with our cosmical neighbors so with us—there can be no materials more desirable than those we have; while for attaining the knowledge of turning them to account there can be no better place than the one to which they are indigenous.

No sufficient reason can be given why this portion of the heavens which we occupy should not rival others in the intelligence of its denizens, because the source of that intelligence, the wisdom of the Great Teacher, though differently manifested according to the constitution of each world, is as perfectly displayed here as elsewhere.

The notion that the numerous small orbs between Mars and Jupiter are fragments of a large one, which by some catastrophe became exploded, is repugnant to the laws of harmony and conservatism that pervade the heavens. The planetoids are said to break the symmetry of the system which requires them to be gathered into one body—a mere conjecture. If one of the purposes of the Creator in the production of worlds be to furnish matter for intelligences to act on, that purpose may require it to vary in its volumes to a greater extent than is yet observable, every orb in that respect being adapted to the capacities and wants of those located on it; in other words, the dimensions of each homestead are determined by the size of the family and the character of its members. The materials of the small planets referred to, assuredly serve as wise a purpose as if they had been rolled into one.

We associate magnificence with magnitude and meanness with minuteness, but God does not. With him nothing is little or large. Dimension! what is it!—an adjunct. Our home is quite a small one compared with many; had it been less, we might have been less pugnacious and not have dishonored it with wars of races and nations. There is no occasion for us to volunteer pity for people on worlds smaller than our own; the happiness of land proprietors does not swell with the expansion of their estates. Knowledge and its best fruits depend not on extent of territory here, nor have we any reason to suppose they do anywhere. There may be Pitcairn-Islanders in the heavens, perfectly happy in their little domicils, who could not be benefited by living on wider spheres; with them knowledge may be further advanced and more condensed than with us. Let the idea be received that the volume of matter in each orb is adapted for those that dwell on it, and there will be no more difficulty in accounting for small than for large ones.

But in the grand panorama might not diversity in the form of worlds be expected, as well as in their dimensions? The human mind could never of itself have suggested any suitable figure, and now that science has shown our heavens to be radiant with *spheres*, the imagination is at a loss to conceive any other outline possible; but as infinite wisdom is infinitely varied, it cannot be confined to one form, even of worlds. We can readily imagine conditions which a globe could not meet: spheres contain the most matter within the least extent of surface; but suppose the largest surface with the least material were required—how realize that? Why, by flattening orbs into plates: their surfaces would then be immensely extended, and multiplied room be afforded for occupants.

The wonderful problem is solved in the rings of Saturn. In them matter is spread into flat, wide, and thin sheets, presenting an area for living beings nearly as extensive as that of all the rest of the planets. One of the magnificent plateaus exceeds twenty-one, and the other thirty-four thousand miles in width, with an average diameter of over one hundred and sixty thousand miles: their estimated thickness being only one hundred miles! What a proof of the resources of mechanical science, as displayed in the heavens, is this! And we may be very sure that those resources in the modelling of worlds are not exhausted here. The interval between a sphere and a plate may be filled up with every degree of variation. Most of our neighboring worlds are oblate spheroids, and why not other forms, starting in other directions from the spherical? Unique in our system as discs are, they may be supposed to prevail elsewhere, on account of the economy of material and the dense populations they can accommodate. Travelling over both sides and the edges, the inhabitants find materials for their chemical, mechanical, and decorative arts, with little trouble.

As in such worlds subterranean and mountain mining would be nearly or wholly superseded, there could be no need, as in fact there could be no development, of a central upheaving power, so indispensable in spheres. The rings of Saturn present the fairest of conceivable fields of locomotive engineering. Had ancient poets heard of them, they would have made them race-courses for the gods. If the smaller one were cut through and opened out, to serve as a plank-bridge to the moon, it would reach as far beyond her as she is from us. As the outer planets are thought to be the oldest, practical science may possibly be further advanced on them than with us. The form of the asteroids has not been determined.

Wherever the idea of worlds being created for factories and their inhabitants for artificers is distasteful, it must be so for want of reflection—nothing else. We all too much confine ourselves, like tethered animals, to small circles of thought. We seldom raise our eyes above the ground, and when we do, we are apt to overlook the fact, that the heavens in their details, and as a whole, are purely mechanical; that celestial are the same as terrestrial mechanics; that our orb is as purely celestial as any other; that all are working parts of one literal, veritable, material machine; that all are of the same original substance, and all moved by one and the same force.

That other orbs are like ours in the physical employments of their occupants, who can doubt? So far as science has progressed, the same elements of light and heat, and the cardinal law of gravitation, are found to pervade all—those in our vicinity and those most distant. Then we are pretty sure that some at least of the chief agents of the arts with us are not confined to us, since, as every one knows, cosmical masses of iron are repeatedly caught on the earth's surface, as she whirls onwards through space.

It is conceded that the composition of aerolites proves them foreign bodies, though their common ingredients—silex, sulphur, magnesia, and the two magnetic metals, nickel and iron—are known to us. That iron is employed in the heavens, meteoritic messengers all but tell us, and they tell us something more. The metal is not found here in a pure state, but has to be laboriously smelted out of stone bearing little resemblance to it; hence the fact of its appearing in its malleable state, is a significant one, indicating, if it indicates anything, that the precious material exists in its purity in other orbs, though not in this; and leading us to infer that the people there have probably not the means of reducing it from ores. Had the means been wanting here, it had been a native metal also here. Let us not do injustice in our thoughts to the Creator, by supposing these specimens come from uninhabited establishments, or that it is stored up where none are benefited by it. He wastes no material—makes not an atom of matter in vain.

Moreover, of metals native in the heavens, iron and nickel are not the only ones. Aerolites furnish traces of copper, cobalt, manganese, and even of tin. Is it then presumptuous to conclude that these substances are elements in the arts of worlds they come from? What other conclusions can be arrived at? To what other conceivable purpose can *metals* be put in worlds in which they are? Of the functions assigned to meteoric couriers one surely is to inform those upon whose territories they alight, that a community of staple occupations unites them to the occupants of other planets, if not of other systems; and to prove this, they bring specimens of staple materials with them. In the samples left with us, iron vastly abounds; an intimation that it plays as important parts in other orbs as it plays on this. Strange, that information of such intense interest, and so wonderfully brought home to us, is not more dwelt on. But many are afraid, and others ashamed, to accept a theory which makes it the business of people in the stars to multiply their comforts and conveniences somewhat as we do—*i. e.* to work in the same materials in which God works.

But if finite beings are through eternity to be engaged in making fresh discoveries, and finding fresh sources of enjoyment in matter, are we to suppose the Creator has ceased from *His* works; that his wisdom in it and power over it are exhausted? No, indeed. On the contrary, we may safely conclude that he is, and for ever will be, as much occupied with it as he has been. Gathering it where dispersed into new worlds, new forms of worlds; placing it under new conditions, imparting to it new properties, and evolving new products from it; stocking it with new faunas and floras, and peopling it with new orders of intelligences. Thus will God pour out his thoughts, and imprint them in that glorious Book of Revelation—the repository of all his conceptions—which is open to sentient beings everywhere, and by which they everywhere become acquainted with him. How else, indeed, can he be so well known as the Author of all things, but in his works, which the more they are studied the more utterance fails, and must for ever fail, to say how great and good they are!

To conclude: Two lessons—one addressed to nations, the other to classes and individuals, may be learned from the preceding pages. First, that the stone of offence against which ancient nations stumbled and fell, was the rock upon which their prosperity and perpetuity should have been based. (See Chap. I. Section III.) The second is a corollary of the first; but enough has been advanced to induce artificers to hold their professions inferior to none, and to urge them to excel in them, remembering that in no character does the Creator so prominently, constantly, and universally appear as in that of THE MECHANICIAN. And if hereafter the parable of the talents is to be literally fulfilled, enlightened elaborators will be counted among the most profitable of servants, because of their activity in discovering and applying for the good of their kind, the great productive agencies located in the orbs on which they dwelt.

THE END.